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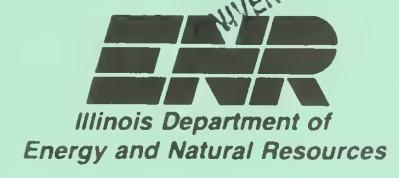


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Beef Research Report and Meeting Proceedings 1990 - 91



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**THE DEPARTMENT OF ANIMAL SCIENCES
UNIVERSITY OF ILLINOIS**

Dennis R. Campion, Head of Department

On behalf of the faculty, staff and students involved in beef cattle research, teaching and extension, I am pleased to introduce the 1990 Beef Cattle Research Report.

This past year has been an exciting and very active year for the Department and the beef cattle program. Construction of the new wings on the Animal Sciences Laboratory will be completed April, 1991. Then renovation of the existing building will be initiated with completion scheduled for December, 1992. The adjacent Plant and Animal Biotechnology Laboratory will be ready January, 1990. Several faculty members will be housed in this Laboratory while ASL is being renovated. Modern animal facilities are featured in PABL which will allow progress to be made in the area of molecular genetics and immunology.

With the hiring of a very capable support staff and the stocking of the Orr Animal Research Center, our beef cattle research program is now fully integrated and operational. Dr. Dan Faulkner continues to be the leader in coordinating the Campus and Center beef cattle operations.

An outstanding faculty which includes Doctors Berger, Fahey, Faulkner, Merchen and Parrett is devoted to beef cattle research. The team is also composed of other collaborating investigators and many graduate students and support personnel. This group is to be commended for their excellent research, teaching and public service activities in the beef cattle area. Their interest in the industry as well as in our beef cattle-oriented students is evidenced by the excellent ways in which they have successfully integrated state-of-the-art teaching with creative and original research, both basic and applied. The "team effort" is geared toward helping our Illinois beef cattle industry be among the best and most innovative in the country. Professors in the areas of rumen microbiology, reproductive physiology and meat science have also made significant contributions to our beef cattle research program.

UNIVERSITY OF ILLINOIS PUREBRED ANGUS HERD

D. F. Parrett, D. B. Faulkner and C. L. Willms

The University of Illinois maintains 60 spring calving purebred Angus cattle. In addition, ten to fifteen replacement heifers are retained each year. The cattle are used in research and teaching. Teaching uses include, beef production, livestock judging and evaluation courses, and special learning classes for undergraduate student research projects. The students gain experience in performance record keeping, animal selection, hands-on laboratory experience, heat-detection, calving and general beef cow herd management.

Most of the research conducted using the cattle is related to applied nutrition and new management techniques. Recent work has concentrated on previous androgenization effects of beef calves, limited creep feeding, various estrous synchronization techniques for beef cows and gene mapping of purebred lines of cattle.

Many clinics, workshops and judging activities also make use of the purebred cattle. The herd also serves as a catalyst for interaction between the Department of Animal Science staff members and the Illinois purebred cattle industry. Performance tested bulls are sold each year through the Illinois Performance Tested Bull Sale. Bulls are also raised and used as herd sires for the commercial cow herds at the Dixon Springs and Orr Research Centers. By raising our own herd sires, we can provide predictable performance and uniformity in the cattle raised for research trials. Of particular importance is the development of a calving ease herd within the Angus herd. These cattle are bred specifically for low birth weight EPD's. This group will become an increasingly important segment of our targeted purebred production program. EPD's (expected progeny differences) are used extensively in designing the breeding programs, with a goal of optimum performance for our environment (table 1).

Many breeders have supported our Angus program and we appreciate their efforts to enhance our program. The University of Illinois Angus cattle have been well accepted in recent years, having the top indexing bull in 1988 and second top indexing yearling bull in 1989 at the Illinois Beef Performance Tested Bull Sale. Also, in the last two Illinois Angus Futurities, the University has consigned one of the top-selling bred females, having the champion heifer in 1988.

TABLE 1. SIRES USED TO PRODUCE THE 1991 CALF CROP

Sire	Expected Progeny Differences			
	Birth	Weanling	Milk	Yearling
Hoff Hi Spade SC491	4.0	50.5	14.3	83.2
R & J Extra 493	3.4	41.5	9.4	70.6
R & J Maxima	4.9	37.6	16.4	53.1
Brost Dan Patch	7.0	51.6	12.8	86.0
Fairfield Dark Star	6.3	52.4	18.8	82.5
SS Rito 0715 OH3	-4.5	20.3	6.2	32.5
R & J Milky Way	.2	44.5	16.3	61.8

EFFECTS OF SYNOVEX-S^a ALONE OR IN COMBINATION WITH FINAPLIX-S^b ON PERFORMANCE AND CARCASS CHARACTERISTICS IN FINISHING STEERS

D. D. Buskirk, D. B. Faulkner and L. L. Berger and C. L. Willms

SUMMARY

Two feedlot trials were conducted to evaluate the effects of implanting at the initiation of the finishing phase and reimplanting at 56-d with Synovex-S alone and in combination with Finaplix-S on feedlot performance and carcass traits. There were no significant ($P>.07$) interactions between initial implant and reimplant on either performance or carcass characteristics. In trial 1, no significant ($P>.05$) differences were observed between initial implant or reimplant treatments in any of the parameters examined. In trial 2, initially implanting with Synovex alone increased ($P<.05$) intake, daily gain, yield grade, and dressing percent, compared to non-implanted animals. Steers initially implanted with Synovex alone had increased ($P<.05$) hot carcass weight and fat thickness compared to non-implanted or Synovex + Finaplix implanted steers. All other carcass measures were similar ($P>.05$) among all treatments. Reimplanting had no statistically significant effect ($P>.05$) on any of the parameters examined.

INTRODUCTION

Finaplix-S is a newly approved implant for feedlot steers which contains 140mg of trenbolone acetate. Since Synovex-S contains different anabolic agents (20mg estradiol benzoate and 200mg progesterone), it has been hypothesized that Finaplix-S and Synovex-S may be additive in enhancing feedlot performance. The objective of these two trials was to examine possible additive effects of these implants on growth and carcass characteristics in feedlot steers at two locations.

PROCEDURE

Trial 1. Seventy-two crossbred steers (719 lb) were blocked by weight then randomly assigned to treatments arranged in a 2 x 3 factorial design for a 126-d finishing trial. Factors were initial implant (Synovex-S or Synovex-S + Finaplix-S) and 56-d reimplant (No implant, Synovex-S or Synovex-S + Finaplix-S). Steers were adjusted to a high concentrate diet using a series of three rations fed 4 days each (Table 1).

Cattle were weighed on days 0, 30, 56 and 126 of the feeding period. Feed was held at a constant level below ad libitum for 2 days before the final unshrunk weight was taken. Steers were slaughtered after 126-d on feed and carcass data was recorded.

Trial 2. One hundred forty-one crossbred steers (671 lb) were randomly assigned to treatments arranged in a 3 x 3 factorial design for a 109-d finishing trial. Factors were initial implant (No implant, Synovex-S or Synovex-S + Finaplix-S) and 56-d reimplant (No implant, Synovex-S or Synovex-S + Finaplix-S). Steers

^aRegistered trademark of Syntex Agribusiness, Inc.

^bRegistered trademark of Roussel Uclaf.

were adjusted to a high concentrate diet using a series of two rations (Table 2). Cattle were weighed on days 0, 56 and 109 of the feeding period. The steers were shrunk for beginning and final weights. Steers were slaughtered after 109-d on feed and carcass data was recorded.

Statistical analysis for both trials were conducted using the GLM procedure of SAS. Performance and carcass data were analyzed using pen as the experimental unit. Treatment mean differences were separated using the F-test for least significant difference.

RESULTS

Trial 1. There were no significant ($P > .07$) interactions between initial implant and reimplant on either feedlot performance or carcass characteristics.

There were no significant ($P > .05$) differences between initial implant or reimplant treatments in any of the performance or carcass traits evaluated (Table 3 and 4). Ribeye area tended ($P = .09$) to be greater for the initial implant of Synovex + Finaplix compared to Synovex alone.

Trial 2. There were no significant ($P > .14$) interactions between initial implant and reimplant on either feedlot performance or carcass characteristics.

Initially implanting Synovex increased ($P < .05$) intake, daily gain, yield grade, and dressing percent compared to steers receiving no implant (Table 5). Initial implants of Synovex increased ($P < .05$) daily gain by 10 percent over non-implanted steers. Increased intake and daily gain caused by Synovex were proportional resulting in similar ($P > .20$) feed/gain ratios to the other treatments. The initial implant of Synovex alone increased ($P < .05$) both hot carcass weight and fat thickness compared to no implant or Synovex + Finaplix treated steers. All other carcass measures were similar ($P > .05$) among treatments.

Reimplanting had no statistically significant effect ($P > .05$) on any of the parameters examined (Table 6). Initially implanting with Synovex alone increased ($P < .05$) fat thickness by .09 in. compared to no implant, however, reimplanting with Synovex tended ($P < .07$) to decrease fat thickness by .05 in. compared to steers not reimplanted. Reimplanting with Synovex alone also tended ($P < .08$) to improve yield grade over animals not receiving an implant at 56-d. Although percent Choice is numerically higher for Synovex + Finaplix than either Synovex or no reimplant these differences are not statistically different ($P > .18$ and $P > .09$ respectively).

In conclusion, implanting Synovex-S alone at the initiation of the finishing phase, increased intake, daily gain, fat thickness, yield grade, hot carcass weight and dressing percent compared to non-implanted steers. Finaplix-S exhibited minimal additive effects when implanted with Synovex-S on feedlot performance and carcass characteristics. Reimplanting at 56-d had no significant effect in these trials.

TABLE 1. COMPOSITION OF DIETS FOR (Trial 1)

Ingredient	1	2	3	4
	-----% Dry matter basis-----			
Corn Silage	--	40	25	10
Corn	15	47	62	77
Corn Gluten	30	--	--	--
Ammoniated Corn Cobs	25	--	--	--
Soybean Hulls	25	--	--	--
Molasses	5	3	3	3
Supplement	--	10	10	10

Supplement Composition:

Corn	45.2
Soybean Meal	30.1
Urea	5.0
Calcium carbonate	10.0
Potassium chloride	5.5
Trace mineralized salt	3.0
Bovatec premix ^a	0.8
Vitamin-mineral premix ^b	0.4

^aSoybean meal carrier with 12.98g Bovatec®/lb premix.^bGuaranteed analysis: 4,540,000 IU/lb vitamin A and 567,000 IU/lb vitamin D₃.

TABLE 2. COMPOSITION OF DIETS FOR (Trial 2)

Ingredient	1	2	3
	-----% Dry matter basis-----		
Ground shelled corn	53	63	74.25
Hay	38	28	19
Soybean meal	7	7	4
Urea	--	--	0.25
Dicalcium phosphate	0.5	0.5	0.5
Limestone	0.75	0.75	1
Trace mineralized salt	0.5	0.5	0.5
Potassium chloride	--	--	0.5
Bicarbonate	0.25	0.25	--

TABLE 3. EFFECT OF INITIAL IMPLANT ON ANIMAL PERFORMANCE AND CARCASS TRAITS (Trial 1)

	Synovex	Synovex + Finaplix	SE
Intake, lb/d	23.4	23.3	.36
Daily gain, lb	3.93	3.98	.08
Feed/Gain	5.96	5.85	.11
Hot Carcass wt., lb	745	743	7.5
Fat Thickness, in.	0.57	0.56	.02
KPH %	2.03	2.00	.08
Ribeye Area, sq. in.	12.91	13.36	.15
Yield Grade	3.08	2.88	.08
Marbling Score ^a	13.06	13.31	.60
Quality grade ^b	9.39	9.44	.28
Percent Choice	55.6	52.8	10.1
Dressing %	61.0	61.0	.24

^aHigh slight = 12, low small = 13, average small = 14, etc.

^bHigh Select = 9, low Choice = 10, average Choice = 11, etc.

TABLE 4. EFFECT OF REIMPLANT ON ANIMAL PERFORMANCE AND CARCASS TRAITS (Trial 1)

	None	Synovex	Synovex + Finaplix	SE
Intake, lb/d	23.4	23.6	23.0	.44
Daily gain, lb	3.92	3.97	3.98	.10
Feed/Gain	5.97	5.95	5.80	.14
Hot Carcass wt., lb	742	753	736	9.2
Fat Thickness, in.	0.59	0.56	0.55	.03
KPH%	1.90	2.06	2.08	.10
Ribeye Area, sq. in.	12.91	13.35	13.14	.18
Yield Grade	3.0	2.95	2.91	.10
Marbling Score ^a	13.63	13.25	12.67	.74
Quality grade ^b	9.50	9.50	9.25	.34
Percent Choice	54.2	58.3	50.0	10.1
Dressing %	60.9	61.0	61.2	.29

^aHigh slight = 12, low small = 13, average small = 14, etc.

^bHigh Select = 9, low Choice = 10, average Choice = 11, etc.

Table 5. EFFECT OF INITIAL IMPLANT ON ANIMAL PERFORMANCE AND CARCASS TRAITS
(Trial 2)

	None	Synovex	Synovex + Finaplix	SE
Intake, lb/d	21.2 ^a	22.3 ^b	21.8 ^{ab}	.49
Daily gain, lb	3.59 ^a	3.96 ^b	3.76 ^{ab}	.11
Feed/Gain	5.91	5.64	5.80	.14
Hot Carcass wt., lb	616 ^a	653 ^b	631 ^a	6.8
Fat Thickness, in.	0.49 ^a	0.58 ^b	0.52 ^a	.01
KPH%	2.01	2.02	2.12	.04
Ribeye Area, sq. in.	11.52	11.89	11.72	.20
Yield Grade	2.82 ^a	3.06 ^b	2.91 ^{ab}	.06
Marbling Score ^c	13.46	13.15	14.04	.55
Quality grade ^d	9.51	9.49	9.85	.24
Percent Choice	55.0	56.0	70.0	7.6
Dressing %	57.8 ^a	59.3 ^b	58.5 ^{ab}	.37

^{a,b}Least square means in the same row with different superscripts differ ($P < .05$).

^cHigh slight = 12, low small = 13, average small = 14, etc.

^dHigh Select = 9, low Choice = 10, average Choice = 11, etc.

TABLE 6. EFFECT OF REIMPLANT ON ANIMAL PERFORMANCE AND CARCASS TRAITS
(Trial 2)

	None	Synovex	Synovex + Finaplix	SE
Intake, lb/d	22.0	21.7	21.6	.59
Daily gain, lb	3.70	3.87	3.75	.13
Feed/Gain	5.96	5.63	5.76	.17
Hot Carcass wt., lb	630	635	636	8.2
Fat Thickness, in.	0.56	0.51	0.52	.02
KPH%	2.01	2.02	2.11	.05
Ribeye Area, sq. in.	11.56	11.79	11.79	.24
Yield Grade	3.04	2.86	2.90	.08
Marbling Score ^a	13.38	13.59	13.68	.66
Quality grade ^b	9.51	9.57	9.76	.29
Percent Choice	51.6	58.2	71.1	9.0
Dressing %	58.2	58.8	58.5	.45

^aHigh slight = 12, low small = 13, average small = 14, etc.

^bHigh Select = 9, low Choice = 10, average Choice = 11, etc.

THE EFFECTS OF CORN VS SOYHULLS LIMITED VS AD LIBITUM INTAKE
AS A CREEP SUPPLEMENT ON CALF PERFORMANCE, SUBSEQUENT
PERFORMANCE DURING GROWING AND FINISHING AND CARCASS CHARACTERISTICS

D. F. Hummel, D. B. Faulkner, D. F. Parrett, and D. D. Buskirk

SUMMARY

Ninety crossbred steers were blocked by age and randomly allotted to one of five treatments to evaluate sources and levels of creep feed on calf performance. In addition, subsequent performance during the growing and finishing stages and carcass characteristics were evaluated. Five treatments consisted of cracked corn (C) and ground soyhulls (S) fed at three levels control (no creep) (O), limited (L), and ad libitum (AL). There were no level by source interactions ($P>.14$). During the creep period there was a linear increase in calf gain with increasing level of creep. Feed efficiency was not effected ($P>.14$) by either source or level during the creep period. However, C had an increase in creep intake over S calves. Intake was increased during the growing phase for AL compared to L steers. Improved finishing period feed efficiency was observed in O over AL steers. Creep source showed minimal effects in all areas evaluated during the growing and finishing stages. Quality grade was increased with AL feeding and C feeding.

INTRODUCTION

On the surface, the traditional creep feeding method seems very attractive. But the added gain due to this method of creep feeding may not be economical. Cremin et al., 1989 reported that limited and ad libitum creep feeding increased daily gain over non creep fed calves 15 and 27%, respectively, while efficiency of utilization of creep feed was not affected. Highly digestible fiber may be more effective for calves consuming high fiber diets (McDonnell, 1983). Therefore the objectives of this trial were to examine the effects of high fiber versus high grain and level of creep feed on daily gain, feed efficiency, subsequent performance during growing and finishing stages, and carcass merit.

PROCEDURE

Ninety commercial Angus-Hereford cows nursing steer calves were utilized in this trial. Calves were blocked by age into three groups and randomly allotted to each of five treatments. The treatments consisted of O, L, and AL levels of C, and S. Crude Protein was 10 and 12% on C and S, respectively. Creep feed was weighed weekly and the salt level adjusted to maintain 1 kg/hd/d intake. Salt level was the same for C and S and averaged 11% for LC and LS to restrict intake. There were three replications per treatment with six cow calf pairs in each of fifteen paddocks. Each paddock was three hectares and consisted of endophyte infected tall fescue. Previous research indicated that these paddocks are uniform in composition so the paddocks were not rotated.

Calves had access to creep feed for a 113-day period from June 20 through October 11, 1989. Initial mid-trial and final calf weights were recorded and calf feed intake was measured. Gain and supplemental gain/feed ($\{\text{supplemented gain-control gain}\}/\text{supplement intake}$) were calculated.

Calves were weaned and placed on a growing ration (Table 1) for 77 days. At the end of the growing period calves were then placed on a finishing ration (Table 2) for 167 days. Weights were recorded at the beginning and end of growing and finishing periods, feed intake was recorded, daily gain and gain/feed were calculated.

At the conclusion of the finishing period calves were slaughtered. Carcass parameters recorded were hot carcass weight, adjusted fat thickness, marbling score, rib eye area, internal fat, and Quality grade. Yield grades were also calculated.

Statistical analysis were conducted using GLM procedure of SAS. Performance and carcass data were analyzed using pen as the experimental unit. Treatment mean differences were separated using F-test for least significant difference.

RESULTS

There were no significant ($P>.14$) interactions between level and source on performance during the creep period, subsequent growing and finishing period or on carcass characteristics. Therefore, only main effects are reported.

During the creep feeding period L calves gained 39% greater ($P<.05$) than O calves, with AL calves exhibiting a 13% gain greater ($P<.05$) than L calves (Table 3). Calves fed C as a creep source had higher ($P<.05$) intake compared to calves fed S (Table 4). There were no significant ($P>.15$) difference in supplement gain/feed between level or source of creep feed.

Evaluating subsequent performance of creep level during the growing period indicates that AL had increase ($P<.05$) intake compared to L steers. During the finishing period, O had an improved gain/feed over L and AL steers (Table 5).

During the growing period, C steers also tended ($P=.06$) to have an increase in daily gain and an improved gain/feed over S steers. However, during the finishing period, S steers had an improved ($P<.05$) gain/feed when compared to C steers (Table 6).

Increasing level of creep feed from O to AL tended ($P=.06$) to increase adjusted fat thickness. Consequently, AL steers also had a higher ($P<.05$) quality grade when compared to O steers (Table 7). Steers that were creep fed C had a higher ($P<.05$) quality grade than S steers (Table 8). All other carcass parameters measured were similar ($P>.12$) at the different levels and sources of creep feed.

In this trial, C and S had similar feed efficiencies during the creep period. There were minimal carry over effects during the growing and finishing stage as well as comparable carcass characteristics. Increased level of creep also had minimal carry over effects during the growing and finishing periods and resulted in similar carcass characteristics.

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McDonnell, M. L., T. Klopfenstein and J. K. Merrill. 1983. Soybean hulls can replace corn in growing rations. Nebraska Beef Cattle Report, University of Nebraska, Lincoln. MP 44:17.

TABLE 1. INGREDIENT COMPOSITION OF GROWING DIET FED TO STEERS

Ingredients	% Dry Matter Basis
Corn	53.0
Corn silage	39.0
Soybean meal	5.75
Urea	.25
Limestone	1.0
Dicalcium phosphate	.50
Salt	.50
Vitamin premix	+

TABLE 2. INGREDIENT COMPOSITION OF FINISH DIET FED TO STEERS

Ingredients	% Dry Matter Basis
Corn	84.0
Chopped hay	10.0
Soybean meal	3.75
Urea	.25
Limestone	1.00
Dicalcium phosphate	.50
Salt	.50
Vitamin Premix	+

TABLE 3. CREEP FEED LEVEL ON CALF PERFORMANCE DURING CREEP PERIOD

Item	Creep Feed Level		
	Control ^a	Limited ^b	Ad Libitum ^b
Supplement intake, Kg/d	---	1.01 ± .07 ^c	2.28 ± .07 ^d
Calf gain, Kg/d	.66 ± .08 ^c	.92 ± .04 ^d	1.04 ± .04 ^e
Supplement gain/feed	.21 ± .03	.14 ± .03	.03 ± .03
Initial wt., Kg	144.8 ± 9.0	134.9 ± 4.4	135.0 ± 4.4
Final wt, Kg	219.8 ± 16.1	238.5 ± 7.9	252.1 ± 7.9

^aMean ± SE; n = 3 pens.

^bMean ± SE; n = 6 pens.

^{c,d,e}Least square means in a row with different superscripts differ (<.05).

TABLE 4. FEED SOURCE ON CALF PERFORMANCE DURING CREEP PERIOD

Item	Creep Feed Source		
	Corn	Soyhulls	SE
Supplement intake Kg/d	1.77 ^a	1.53 ^b	.07
Calf gain, Kg/d	.98	.94	.04
Supplement gain/feed	.18	.17	.03
Initial wt., Kg	133.8	139.4	4.5
Final wt, Kg	245.1	246.2	8.3

^{a,b}Least square means in a row with different superscripts differ (P<.05).

TABLE 5. CREEP FEED LEVEL ON SUBSEQUENT PERFORMANCE DURING GROWING AND FINISHING PERIOD

	Creep Feed Level		
	Control ^a	Limited ^b	Ad Libitum ^b
<u>Growing</u>			
Intake, Kg/day	6.10 ± .08	6.13 ± .04 ^c	6.26 ± .04 ^d
Gain, Kg/day	.42 ± .12	.69 ± .05	.71 ± .05
Gain/feed	.07 ± .02	.11 ± .01	.11 ± .01
Initial wt, Kg	219.8 ± 16.1	238.5 ± .06	252.1 ± .06
Final wt, Kg	252.4 ± 11.3 ^c	291.3 ± 5.6	306.4 ± 5.6 ^d
<u>Finishing</u>			
Intake, Kg/d	8.33 ± .47	9.26 ± .23	9.44 ± .23
Gain, Kg/day	1.35 ± .09	1.20 ± .05	1.20 ± .05
Gain/feed	.16 ± .01 ^c	.13 ± .005 ^d	.13 ± .005 ^d
Final wt, Kg	477.3 ± 21.1	491.3 ± 10.4	506.4 ± 10.4

^aMean ± SE; n = 3 pens.

^bMean ± SE; n = 6 pens.

^{c,d}Least square means in a row with different superscripts differ (P<.05).

TABLE 6. CREEP FEED SOURCE ON SUBSEQUENT PERFORMANCE DURING GROWING AND FINISHING PERIOD

Item	Creep Feed Source		SE
	Corn	Soyhulls	
<u>Growing</u>			
Intake, Kg/day	6.21	6.14	.04
Gain, Kg/day	.73	.56	.05
Gain/feed	.12	.09	.01
Initial wt, Kg	241.1	246.15	8.31
Final wt, Kg	301.27	289.11	5.77
<u>Finishing</u>			
Intake, Kg/day	9.44	8.97	.24
Gain, Kg/day	1.19	1.23	.02
Gain/feed	.13 ^a	.14 ^b	.003
Final wt, Kg	499.92	494.62	6.97

^{a,b}Least square means in a row with different superscripts differ (P<.05).

TABLE 7. CREEP FEED LEVEL ON CARCASS CHARACTERISTICS

Item	Creep Feed Level		
	Control ^a	Limited ^b	Ad Libitum ^b
Quality grade	9.75 ± .30 ^d	10.56 ± .15 ^{d,e}	10.67 ± .15 ^e
Yield grade	2.94 ± .24	3.05 ± .12	3.24 ± .12
Fat thickness, in.	.39 ± .05	.47 ± .02	.51 ± .02
Rib eye area, sq. in.	11.26 ± .50	11.79 ± .25	11.90 ± .25
Internal fat, %	2.8 ± .27	2.7 ± .13	3.0 ± .13

^aMean ± SE; n = 3 pens.

^bMean ± SE; n = 6 pens.

^c9 = high Select; 10 = high Choice.

^{d,e}Least square means in a row with different superscripts differ (P<.05).

TABLE 8. CREEP FEED SOURCE ON CARCASS CHARACTERISTICS

Item	Creep Feed Source		SE
	Corn	Soyhulls	
Quality grade ^a	10.7 ^a	10.2 ^b	.11
Yield grade	3.17	3.04	.12
Fat thickness, in.	.50	.45	.02
Rib eye area, sq. in.	11.88	11.72	.25
Internal fat, %	2.88	2.80	.13

^a = Low Choice.

^{b,c}Least square means in a row with different superscripts differ (P<.01).

EFFECTS OF ALKALINE HYDROGEN PEROXIDE-TREATED WHEAT STRAW AND CORN SILAGE SUPPLEMENTED WITH DIFFERENT LEVELS AND SOURCES OF PROTEIN ON PERFORMANCE OF GROWING CATTLE AND SUBSEQUENT FINISHING PHASE PERFORMANCE

C. L. Willms, L. L. Berger, N. R. Merchen and G. C. Fahey, Jr.

SUMMARY

An 84-d growth trial with 162 crossbred steers (565 lb) was conducted to compare the feeding value of alkaline hydrogen peroxide-treated wheat straw (AHP-WS) to corn silage (CS) and the efficacy of different supplemental protein sources and levels in diets based on these roughages. Subsequently, the cattle were finished on a common finishing diet to evaluate carry-over effects of growing phase dietary regimen. Finishing phase performance was evaluated for a constant time on feed (105 d) or fed to similar slaughter weight. A completely randomized design with a 3x3 factorial arrangement of treatments was used. Factors were roughage source [CS, AHP-WS and a 1:1 mixture of CS and AHP-WS (MIX)] and protein treatment [13% and 11% crude protein (CP) with supplemental CP provided by soybean meal (13-SBM) and (11-SBM) and 11% CP with a combination of urea, corn gluten meal and fish meal providing the supplemental CP (U:CG:F)]. AHP-WS decreased ($P<.01$) dry matter intake 1.16 to 1.46 lb/d compared to CS and MIX, respectively. With increasing AHP-WS in the diet, daily gain (ADG) and gain/feed (G/F) decreased ($P<.01$). There was no difference in performance due to protein treatment. Finishing phase ADG and G/F were not affected by growing phase dietary regimen when steers were fed for 105 d. However, MIX-fed steers consumed less ($P<.01$) dry matter in the finishing phase (fed to both end points) than AHP-WS-fed steers. Steers fed CS or AHP-WS in the growing phase had higher ADG ($P<.04$) and tended to have higher ($P=.06$) G/F in the finishing phase than MIX-fed steers when fed to a similar weight. Steers fed AHP-WS tended to have carcasses with lower ($P=.06$) yield grade than MIX-fed steers. These data indicate that steers fed AHP-WS in the growing phase did not compensate for lower growing phase performance in the finishing phase.

INTRODUCTION

The alkaline hydrogen peroxide treatment process has been shown to be very effective in increasing the digestibility of crop residues. Lewis et al. (1987) reported that steers fed alkaline hydrogen peroxide-treated wheat straw (AHP-WS)-based diets performed similarly to cattle fed corn silage (CS)-based diets. However, in this study AHP-WS was pelleted and prepared by soaking wheat straw in sodium hydroxide and hydrogen peroxide rather than the current procedure of spraying the chemicals onto wheat straw while mixing in a horizontal mixer. Further research has shown AHP-WS to be equal to alfalfa hay and CS as a roughage source in cattle finishing diets (Willms et al., 1989a).

Willms et al. (1989b) reported that 12% crude protein (CP) maximized nitrogen (N) retention (% of N intake) and fiber digestibility in 70% AHP-WS diets fed to growing lambs. Cecava et al. (1989) demonstrated with cannulated lambs that feeding slowly degraded supplemental protein sources with complementary amino acid profiles shifted the profile of amino acids entering the intestine compared

to soybean meal supplementation in AHP-WS-based diets. These workers used corn gluten meal and blood meal as protein sources rich in sulfur-containing amino acids and lysine, respectively. Methionine and lysine have been implicated as limiting amino acids in ruminant diets. Willms et al. (1989c) reported that lambs fed AHP-WS-based diets had improved performance when supplemented with protein sources with complementary amino acid profiles.

The objectives of this study were to compare AHP-WS prepared by the current procedure to CS in cattle growing diets and to evaluate protein supplementation with a combination of protein sources containing complementary amino acid profiles vs soybean meal in diets based on these roughages. A final objective was to evaluate carry-over effects of growing phase dietary regimen on subsequent finishing phase performance.

PROCEDURE

A completely randomized experimental design with a 3x3 factorial arrangement of treatments was used to allot 162 crossbred steers (565 lb) to treatment in an 84-day growth trial. Factors were roughage source and protein treatment. Roughage sources were CS, AHP-WS and a 1:1 mixture of CS and AHP-WS (MIX) with the roughage level set at 66% of diet dry matter. Dietary CP level and source of supplemental CP for the protein treatments were 13% CP and soybean meal (13-SBM); 11% CP and soybean meal (11-SBM); and 11% CP and a combination of protein sources (U:CG:F). The U:CG:F diets were formulated such that urea, fishmeal and a combination of corn and corn gluten meal each provided 1/3 of the supplemental CP (Table 1). Corn and corn gluten meal are high in sulfur-containing amino acids and fish meal is high in lysine. The 13-SBM treatment served as a positive control. Based on N balance data with lambs (Willms et al., 1989b), the 11% CP treatments were expected to be slightly below protein requirements. All diets were formulated to contain .45% calcium, .30% phosphorus, .80% potassium, .30% trace mineralized salt with selenium, 30,000 IU/hd/d vitamin A and 200 mg/hd/d lasalocid.

The AHP-WS was prepared by grinding large round bales of wheat straw in a tub grinder (3/8 in. screen), then conveying ground straw into a stainless steel horizontal mixer. Each batch contained 235 ± 5 lb of wheat straw (90% DM). While mixing, water, sodium hydroxide (50% solution) and hydrogen peroxide (50% solution) were sprayed onto the wheat straw sequentially to achieve a final product with approximately 65% DM, 5% sodium hydroxide, 2% hydrogen peroxide and a pH of 11.5. Wheat straw, water and sodium hydroxide were mixed 2 min prior to hydrogen peroxide addition. After hydrogen peroxide addition and a final 3 min mixing, treated wheat straw was discharged from the mixer and transported to an oxygen limiting silo for storage.

Diets were fed once daily ad libitum and orts weighed as necessary and analyzed for dry matter. Cattle were weighed at 28-d intervals. Prior to the final 84-d weight, DM intake was equalized for four days by feeding the 13-SBM-CS diet slightly below ad libitum to all cattle. This was done to equalize gut fill and eliminate water retention that could have occurred on the high sodium-containing AHP-WS diets. One steer was removed from the trial for reasons not related to treatment.

Following the growing phase, all cattle were fed a common high concentrate finishing diet (Table 2). Performance was evaluated both at constant time on feed (105 d) and at a similar ending weight. Dry matter intake was equalized across all pens for two days prior to the 105 d weighing to equalize gut fill. When evaluating performance at a similar ending weight, final live weight was adjusted using a constant dressing percentage. Carcass data for determining quality and yield grades were obtained.

Statistical analysis was conducted using a GLM procedure of SAS for a completely randomized design. Variables included in the fixed model were roughage source, protein treatment and roughage source*protein treatment interaction. Performance and carcass data were analyzed using pen and animal as the experimental unit, respectively. Treatment mean differences were separated using the F-test for least significant difference.

RESULTS

Growing phase

Steers fed AHP-WS had lower ($P < .01$) dry matter intake (DMI) than steers fed CS or MIX (Table 3). Average daily gain (ADG) and efficiency of gain (G/F) decreased ($P < .01$) with increasing AHP-WS in the diet. Several reasons could exist for the contrast in these results to those of Lewis et al. (1987). First, the AHP-WS was prepared differently. These workers soaked wheat straw in sodium hydroxide and hydrogen peroxide solutions which could allow for a more complete reaction with the cell wall components of the wheat straw resulting in higher digestibility. Further, the AHP-WS was pelleted and could have a faster passage rate, allowing for greater intake. Secondly, an ionophore, lasalocid, was fed in this study, but not in the study of Lewis et al. (1987). Ionophores are involved in exchanging cations (Na^+ and K^+) across bacterial cell walls. Several workers have shown depressed digestibility with ionophores in high sodium and/or potassium-containing diets (Schwingel et al., 1989). Thirdly, because of the high sodium level in the AHP-WS, cattle fed AHP-WS had wetter pens from increased urination than cattle fed CS. This occurred despite a concerted effort to clean and bed these pens frequently. During cold weather, wetter pens would cause steers to have higher maintenance energy requirements and decrease performance. Nevertheless, it should be noted that steers fed 66% of diet dry matter as AHP-WS gained 2.38 lb/d. Calculated expected gain (using NRC, 1984) of steers fed 66% native wheat straw instead of AHP-WS in otherwise identical conditions (steer weight, dry matter intake and 10% increased ADG due to lasalocid) is 1.01 lb/d. The alkaline hydrogen peroxide treatment process is apparently very effective although performance of AHP-WS-fed steers did not equal that of CS-fed steers. However, CS is approximately 50% grain. In effect, CS-fed steers were receiving a 67% concentrate diet (66/2 + 34).

There was no difference in performance due to protein treatment (Table 4). There was, however, a tendency ($P = .07$) for the U:CG:F treatment to gain less than the 13-SBM treatment. We have no explanation for this decrease. In designing this experiment, we theorized that a roughage source*protein treatment interaction would be detected. We expected U:CG:F to improve post-ruminal supply and/or profile of amino acids and thereby improve performance with the AHP-WS-based diet since AHP-WS is nearly devoid of true protein. Improved performance with U:CG:F was not expected with CS-based diets because CS provides a significant portion of the total dietary CP. Improved performance with U:CG:F was not detected in

AHP-WS diets, probably because protein was overfed for the level of performance obtained on AHP-WS. Thus, differences in post-ruminal supply or quality of protein were masked.

Finishing phase

Since steers fed AHP-WS gained slower during the growing phase, it was of interest to determine if they would compensate in the finishing phase. Corn silage-fed steers were heavier than AHP-WS-fed steers entering the finishing phase and thus finished sooner. Therefore, performance was evaluated at both a constant time on feed and at a similar ending weight. Steers fed MIX and AHP-WS during the growing phase were slaughtered 13 d after CS-fed steers. Based on predicted performance from the most recent 28 d weighing interval, this time frame should have allowed for similar slaughter weights. However, due to extreme hot weather, MIX and AHP-WS fed steers did not gain as predicted and this precluded evaluation of performance at as similar weight as desired. Therefore, evaluation of finishing phase performance at a constant time on feed is confounded by differences in composition of gain while performance evaluation at similar slaughter weight is confounded by environmental effects.

There were no differences in finishing phase DMI, ADG or G/F between steers fed CS or AHP-WS at either end point, although steers fed AHP-WS had numerically higher values (Table 5). Steers fed MIX had lower ($P<.01$) DMI than AHP-WS fed steers at both end points. When fed to similar weights, MIX-fed steers had lower ($P<.04$) ADG and tended ($P=.06$) to have lower G/F. We have no biological explanation for decreased performance of MIX-fed steers. Steers fed AHP-WS tended ($P=.06$) to have carcasses with a lower yield grade (Table 6). These data indicate there was not compensatory growth by the AHP-WS-fed cattle during the finishing phase. However, this would also indicate that high dietary sodium levels in the growing phase were not detrimental to subsequent performance. There were no differences in finishing phase performance or carcass characteristics due to growing phase protein treatment (data not shown).

CONCLUSIONS

Steers fed high roughage diets in the growing phase have reduced performance when fed AHP-WS vs CS-based diets. There were no detrimental carry-over effects on subsequent finishing phase performance due to the high sodium content of the AHP-WS-based diets fed in the growing phase. However, steers fed AHP-WS-based diets did not exhibit compensatory growth in the finishing phase despite poorer performance in the growing phase. There is no benefit to feeding supplemental protein sources with complementary amino acid profiles in either CS or AHP-WS-based diets when the dietary crude protein level is at least 11%.

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Table 1. Growing phase diet composition

Ingredient	CS ^a			MIX ^a			AHP-WS ^a		
	1 ^b	2 ^b	3 ^b	1	2	3	1	2	3
Corn silage	66.0	66.0	66.0	33.0	33.0	33.0			
AHP-WS				33.0	33.0	33.0	66.0	66.0	66.0
Corn	24.52	28.97	30.71	19.86	24.31	26.60	15.21	19.66	22.48
Soybean meal	7.76	3.31		12.53	8.08		17.29	12.84	
Corn gluten			.17			2.94			5.71
Fish meal			1.11			2.51			3.91
Urea			.34			.60			.85
Dicalcium phosphate	.16	.16		.37	.37	.09	.58	.58	.18
Limestone	.66	.66	.54	.56	.56	.36	.46	.46	.17
TM salt ^c	.30	.30	.30	.30	.30	.30	.30	.30	.30
Potassium chloride	.21	.21	.21	.21	.21	.21	.21	.21	.21
Vitamin premix ^d	.04	.04	.04	.04	.04	.04	.04	.04	.04
Lasalocid premix ^e	.13	.13	.13	.13	.13	.13	.13	.13	.13

^aCS = corn silage, MIX = 1:1 mixture of corn silage and alkaline hydrogen peroxide-treated wheat straw and AHP-WS = alkaline hydrogen peroxide-treated wheat straw.

^b1 = 13% crude protein with soybean meal as supplemental protein source, 2 = 11% crude protein with soybean meal as supplemental protein source and 3 = 11% crude protein with combination of urea, corn gluten meal and fish meal as supplemental protein sources.

^cTM salt = trace mineralized salt. Composition: 95.0% sodium chloride, 1.58% zinc, .80% manganese, .55% iron, .056% copper, .007% iodine, .006% cobalt and .002% selenium.

^dContains 4,540,000 IU vitamin A and 567,000 IU vitamin D₃.

^eProvides 10 g lasalocid/lb premix.

Table 2. Finishing phase diet composition

Ingredient	% Dry matter basis
Corn silage	10
Dry corn	77
Liquid molasses	3
Supplement	10
<u>Supplement composition</u>	
Dry ground corn	44.2
Soybean meal	30.9
Urea	5.0
Limestone	10.0
Potassium chloride	5.5
Trace mineralized salt ^a	3.0
Vitamin premix ^b	.4
Lasalocid premix ^c	1.0

^aComposition: 95.0% sodium chloride, 1.58% zinc, .80% manganese, .55% iron, .056% copper, .007% iodine, .006% cobalt and .002% selenium.

^bContains 4,540,000 IU vitamin A and 567,000 IU vitamin D₃.

^cProvides 10 g lasalocid/lb premix.

Table 3. Effects of roughage source on dry matter intake, daily gain and gain/feed during the 84-d growing phase

Item	Roughage source ^a			SE
	CS	Mix	AHP-WS	
Initial weight, lb	569.4	565.9	560.4	3.80
Final weight, lb	857.3	811.4	760.7	6.79
Dry matter intake, lb/d	17.64 ^b	17.94 ^b	16.48 ^c	.21
Daily gain, lb/d	3.43 ^b	2.92 ^c	2.38 ^d	.07
Feed/gain	5.16 ^b	6.16 ^c	6.95 ^d	.16
Gain/feed	.194 ^b	.163 ^c	.145 ^d	.004

^aCS = corn silage, MIX = 1:1 mixture of corn silage and alkaline hydrogen peroxide-treated wheat straw and AHP-WS = alkaline hydrogen peroxide-treated wheat straw.

^{b,c,d}Means in the same row with different superscript letters differ (P<.01).

Table 4. Effects of protein treatment on dry matter intake, daily gain and gain/feed during the 84-d growing phase

Item	Protein treatment ^a			SE
	13-SBM	11-SBM	U:CG:F	
Initial weight, lb	560.0	565.5	570.2	3.47
Final weight, lb	812.5	810.1	806.8	15.21
Dry matter intake, lb/d	17.37	17.47	17.22	.21
Daily gain, lb/d	3.01 ^b	2.91 ^{b,c}	2.82 ^c	.07
Feed/gain	5.89	6.16	6.22	.16
Gain/feed	.173	.166	.164	.004

^a13-SBM = 13% crude protein with soybean meal as supplemental protein source, 11-SBM = 11% crude protein with soybean meal as supplemental protein source and U:CG:FM = 11% crude protein with combination of urea, corn gluten meal and fish meal as supplemental protein sources.

^{b,c}Means in the same row with different superscript letters differ (P=.07).

Table 5. Effects of growing phase roughage source on subsequent finishing phase performance

Item	Growing phase roughage source ^a			SE
	CS	MIX	AHP-WS	
Initial weight, lb	857.2	811.6	760.8	6.80
<u>105 d performance</u>				
Final weight, lb	1218.7	1170.9	1140.8	12.31
Dry matter intake, lb/d	21.25 ^{b,c}	20.63 ^c	21.92 ^b	.292
Daily gain, lb/d	3.44	3.42	3.62	.087
Feed/gain	6.19	6.05	6.06	.113
Gain/feed	.162	.166	.165	.003
<u>Physiological end point</u>				
Final weight, lb	1221.0	1190.1	1174.7	12.82
Time on feed, d	105	118	118	
Dry matter intake, lb/d	21.25 ^{b,c}	20.72 ^c	21.93 ^b	.276
Daily gain, lb/d	3.46 ^d	3.21 ^e	3.51 ^d	.081
Feed/gain	6.14 ^f	6.48 ^g	6.27 ^f	.113
Gain/feed	.163 ^f	.155 ^g	.160 ^f	.003

^aCS = corn silage, MIX = 1:1 mixture of corn silage and alkaline hydrogen peroxide-treated wheat straw and AHP-WS = alkaline hydrogen peroxide-treated wheat straw.

^{b,c}Means in the same row with different superscript letters differ (P<.01).

^{d,e}Means in the same row with different superscript letters differ (P<.04).

^{f,g}Means in the same row with different superscript letters differ (P=.06).

Table 6. Effects of growing phase roughage source on carcass characteristics of steers fed a common finishing diet

Item	Growing phase roughage source ^a			SE
	CS	Mix	AHP-WS	
Fat thickness, in	.62	.62	.56	.026
Yield grade	3.60 ^c	3.54 ^{b,c}	3.31 ^b	.107
Rib eye area, sq in	12.53	12.47	12.53	.199
Internal fat, %	2.81	2.90	2.76	.062
Marbling score ^d	14.69	15.28	14.29	.458
Quality grade ^e	10.20	10.41	9.99	.179
Dressing %	62.11	62.06	62.42	.254

^aCS = corn silage, MIX = 1:1 mixture of corn silage and alkaline hydrogen peroxide-treated wheat straw and AHP-WS = alkaline hydrogen peroxide-treated wheat straw.

^{b,c}Means in the same row with different superscript letters differ (P=.06).

^dScale of 1-30 where slight plus = 12, small minus = 13, small average = 14, small plus = 15, etc.

^eScale of 1-15 where high select = 9, low choice = 10, average choice = 11, high choice = 12, etc.

EFFECTS OF INCREASING CRUDE PROTEIN LEVEL ON INTESTINAL SUPPLY OF AMINO ACIDS IN LAMBS FED ALKALINE HYDROGEN PEROXIDE-TREATED WHEAT STRAW-BASED DIETS

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SUMMARY

Five St. Croix wethers (34 kg) fitted with ruminal, duodenal and ileal cannulae were used in a 5 x 5 Latin square experiment to study the effects of increasing crude protein (CP) level on the intestinal supply of nitrogen (N) and amino acids (AA) and site and extent of nutrient digestion when fed an alkaline hydrogen peroxide-treated wheat straw-based diet. Treatments were 8, 10, 12, 14 and 16% CP. Protein level was increased by substituting soybean meal for corn. Chromic oxide was used as a digesta flow marker and purines as a bacterial marker. Protein level had no effect on ruminal CP degradability. True ruminal organic matter digestibility increased ($P < .01$) linearly and ruminal ammonia-N concentration increased ($P < .01$) quadratically with increasing CP level. Total, bacterial and nonbacterial N and AA flows to the duodenum increased ($P < .05$) linearly with increasing CP level. Duodenal AA profile (g/100 g AA) was slightly shifted with the essential AA valine, isoleucine, phenylalanine, lysine and arginine increasing ($P < .05$) with increasing CP level. Methionine decreased ($P < .05$) in proportion to other AA with increasing CP level. All flows of indispensable AA increased with increasing CP level. Apparent intestinal N and AA disappearance increased linearly ($P < .05$) while apparent total tract N digestibility increased ($P < .01$) quadratically with increasing CP level.

INTRODUCTION

Previous research has shown alkaline hydrogen peroxide-treated wheat straw (AHPWS) to be a highly fermentable feedstuff (Kerley et al., 1986; Willms et al., 1989). However, it is essentially devoid of true protein. Utilization of AHPWS in practical ruminant diets requires development of recommendations for optimal protein supplementation. Previous research established that maximal nitrogen (N) retention (% of N intake) by lambs fed 70% AHPWS-based diets was achieved at 12% dietary crude protein (CP) when a common protein source (soybean meal) was used (Willms et al., 1989). However, in order to develop a more meaningful means of expressing protein requirements for ruminants, data on intestinal supply of amino acids (AA) must be generated. Therefore, the objective of this study was to characterize the flow of AA to the duodenum and determine site and extent of nutrient digestion due to increasing dietary protein with a standard protein source (i.e., soybean meal).

PROCEDURES

Five cannulated (ruminal, duodenal and ileal) St. Croix wethers (34 kg) were allotted to treatment in a 5 x 5 Latin square design. Diets were formulated to contain 8, 10, 12, 14 and 16% CP (Table 1). Actual CP content determined by analysis was slightly higher than planned for all treatments. Protein level was adjusted by substituting soybean meal for

corn. All diets were 65% AHPWS:35% concentrate. Since low CP levels can decrease dry matter intake, a preliminary period was conducted to establish ad libitum intake of the 8% dietary CP treatment for each wether. Wethers were then fed at 90% ad libitum two times daily at 12 h intervals. Dry matter intake averaged 2.6% of body weight. At time of feeding wethers were dosed with 1.5 g chromic oxide (3 g/d) so that sites of nutrient digestion and intestinal flows could be quantified.

Each period was 16 d in length, with 10 d adjustment to diet and 6 d sample collection. Feed, duodenal and ileal digesta samples and feces were collected on d 11-16. Duodenal (100 ml) and ileal (50 ml) digesta samples were collected at 2, 6 and 10 h and 4, 8 and 12 h post AM feeding on alternate days during the collection phase and composited by animal. Samples were dried at 55 C (feed and feces) or freeze dried (duodenal and ileal digesta) and ground through a 1 mm screen using a Wiley mill. All samples were analyzed for dry matter, organic matter (OM), N, neutral detergent fiber (NDF) and acid detergent fiber (ADF). Ruminal samples were collected once daily such that each of the above hours post AM feedings were represented and pH was immediately determined. A 50 ml subsample was acidified with 6N HCl, frozen and subsequently analyzed for ammonia and volatile fatty acid concentration. From the remainder (250 ml), a bacteria rich fraction was isolated. Concentrations of AA were determined for duodenal, ileal and bacterial samples. Duodenal flows of N and AA of bacterial and nonbacterial origin were calculated using purines as a bacterial marker. Bacterial N:purine ratio and AA composition did not differ ($P > .05$) due to diet. Therefore, mean bacterial composition values were used in calculations of bacterial flows.

Data were analyzed as a 5 x 5 Latin square design. Effects of CP level were determined by linear and quadratic orthogonal contrasts using a GLM procedure of SAS. Terms in the model were period, animal and CP level. One animal died after the second period resulting in three missing observations (8, 10 and 12% CP treatments). Ruminal pH, ammonia-N and volatile fatty acid concentrations were analyzed as a split plot in time.

RESULTS AND DISCUSSION

Organic matter digestion data are presented in Table 2. Organic matter intake decreased linearly ($P < .01$) with increasing CP level since each lamb was fed at 90% ad libitum and there were three missing observations. However, this has no biological significance since the difference in OM intake among treatments was only 10 g. There was no difference in apparent OM digestion in the stomach, but true OM digestion in the stomach increased linearly ($P < .01$) with increasing CP level. There was no difference in small intestinal OM digestion. Hindgut OM fermentation tended ($P < .10$) to be higher and thereby compensated for lower stomach digestion on the 8% CP treatment. This resulted in only a tendency ($P < .10$) for total tract OM digestibility to increase linearly with increasing CP level.

Neutral detergent fiber intake (Table 3) decreased linearly ($P < .01$) for the same reasons as OM intake and has no biological significance. Digestion of NDF mirrored OM digestion with linear ($P < .05$) increases in stomach and total tract digestion and a linear decrease

($P < .05$) in hindgut fermentation with increasing CP level. Stomach NDF digestion was approximately 62% for 8 and 10% CP treatments and increased to 67% for 12, 14 and 16% CP levels. There was no digestion of NDF in the small intestine. Total tract NDF digestion ranged from 70.8% on the 8% CP diet to 75.0% on the 12 and 16% CP diets. There were no differences in ADF digestion (data not shown) due to treatment although numerical values mirrored NDF digestion. Total tract ADF digestion averaged 53.3%.

Nitrogen intake ranged from 11.3 g/d on the 8% CP diet to 25.2 g/d on the 16% CP diet (Table 4). Total N flow to the duodenum increased linearly from 17.7 to 24.2 g/d with increasing CP level. There was considerable N recycling by lambs fed the low protein diets. Nitrogen flow to the duodenum on the 8 and 10% CP diets was 156 and 126% of N intake, respectively. Bacterial N flow increased linearly ($P < .01$) as dietary CP increased, but tended toward a quadratic effect ($P = .06$) with the minimal value being 13.4 g/d on the 12% CP diet. This increase in bacterial N flow was apparently due to increased ruminal OM digestion since there was no difference ($P > .05$) in efficiency of bacterial protein synthesis expressed either as g/100 g of apparently or truly digested OM in the rumen. These results are consistent with other studies at the University of Illinois where bacterial N flow was not affected by ruminal ammonia-N concentration less than 5 mg/dl, but increased with increasing OM digestion with no differences in efficiency of bacterial protein synthesis (McCarthy et al., 1989). In this study, efficiency of bacterial protein synthesis was not different across treatments despite a quadratic increase ($P < .01$) in mean ruminal ammonia-N concentration from 3.3 to 12.8 mg/dl for the 8 to 16% CP diets, respectively (Table 5). When evaluated by hour, ruminal ammonia-N concentration on the 8% CP diet was below 5 mg/dl through 10 h post feeding and near or below 5 mg/dl through 6 h postfeeding on the 10% CP diet. Duodenal nonbacterial N flow (% of N intake, Table 4) was unaffected by protein level. Thus, the proportion of intake CP ruminally degraded was unaffected by CP level. Ruminal CP degradation averaged 69% across treatments. It follows that nonbacterial N flow (g/d) increased with increasing CP level simply due to greater N intake. There was no difference in N flow at the ileum or fecal N excretion which resulted in a linear increase ($P < .05$) in apparent small intestinal N digestion and a quadratic increase ($P < .01$) in apparent total tract N digestion as CP level increased. These increases can be partially explained by a dilution of endogenous protein secretions. Further implications are that the intestine has adequate capacity to digest and absorb increasing levels of N-containing compounds. Nitrogen digestion in the hindgut was unaffected ($P > .10$) by treatment.

Amino acid flows to the duodenum followed the same trends as N flow (Table 6). Increasing CP level resulted in linear increases ($P < .01$) in total, essential and nonessential duodenal AA flows from bacterial and nonbacterial origin. While it is biologically impossible to have negative flows of nonbacterial AA, negative flows (not significantly different from zero) were obtained for the 8% CP treatment. These may be a result of inaccuracies related to the digesta flow marker. Nonbacterial AA flows were essentially zero for both the 8 and 10% CP diets. This means that all the nonbacterial N flow to the duodenum of lambs fed these diets was non-amino acid-N. The flow of each essential AA increased linearly ($P < .01$ or $P < .05$) as dietary CP level increased. With more than a doubling of N intake, flows of lysine, leucine and valine increased 6.0, 5.6 and 4.7 g/d,

respectively, while methionine and histidine flows increased only .7 and 1.6 g/d, respectively. The flow of methionine on the 8 and 10% CP diets may be inflated in relation to other treatments since all AA flow originated from bacteria. Diaminopimelic acid (DAPA) is found in the cell walls of bacteria and co-elutes with methionine from the column used for AA analysis. Nevertheless, there would still only be slight increases in methionine flow without the confounding effects of DAPA. It would appear that methionine was the first limiting AA since it had the lowest increase in flow per unit increase in dietary CP level.

There were only subtle changes in the profile of AA (g/100 g total AA) entering the duodenum (Table 7). The profile of duodenal AA was similar to published values for bacterial AA profiles. Valine, isoleucine, phenylalanine, lysine, arginine and aspartic acid increased linearly ($P < .01$ and $P < .05$) in relation to other AA while methionine, glutamic acid, proline and alanine decreased linearly ($P < .01$ and $P < .05$). In general, the proportion of essential AA increased and nonessential AA decreased in relation to total AA as dietary CP level increased. The biological significance of these changes may be unimportant since AA composition of bacteria and digesta can be measured much more accurately than the flow of digesta. Profile of methionine may be inflated on the low protein diets because of confounding with DAPA. Yet the true profile of methionine (without DAPA) could at best be unaffected (rather than decreasing) by increasing CP level. The flows and profile of individual amino acids to the duodenum underscores the difficulty in changing quality of protein when a high ruminally degradable protein source is fed. If methionine is the first limiting AA in bacteria, feeding a highly ruminally degradable protein source such as soybean meal does little to enhance methionine flow to the duodenum.

Net small intestinal disappearance of total, essential and nonessential AA whether expressed as g/d or as a percentage of AA entering the duodenum increased linearly ($P < .05$) with increasing CP level (Table 8). Essentially all the increased flow of AA resulting from increased CP level were absorbed in the small intestine. Increasing dietary CP level from 8 to 16% increased total AA flow 66 g/d (145.1 - 79.1, Table 6) while total AA disappearance from the small intestine increased 64.8 g/d (100.8 - 36.0, Table 8). The intestine apparently has adequate capacity to digest and absorb large quantities of AA. The increase in percentage disappearance of AA with increasing protein level was apparently due to a dilution of endogenous protein secretions.

In summary, because AHPWS is essentially devoid of true protein, nearly all dietary protein is supplied by supplemental protein sources. When a highly degradable protein source is fed, the profile of AA entering the intestines is inherently similar to microbial protein and there is little or no opportunity to enhance the biological value of protein entering the small intestines. Whatever AA are limiting in bacterial protein (presumably methionine) will be the AA limiting production. In contrast, an AHPWS-based diet lends itself to use of ruminally resistant protein sources with complementary AA profiles (Cecava et al., 1990). These researchers demonstrated that combinations of blood meal (high lysine source) and corn gluten meal (high methionine source) increased total flows of amino acids and the profile of lysine and methionine entering the duodenum compared

to soybean meal supplemented AHPWS-based diets. Growth data with ram lambs fed a combination of fish meal (high lysine) and distillers dried grains (high methionine) as supplemental protein sources in AHPWS-based diets support this work (Willms et al., 1990).

When viewing this study in conjunction with a previous N balance study using the same treatments and similar lambs (Willms et al., 1989), increasing the flow of AA entering the duodenum does not necessarily translate into greater animal performance. In this study, N and AA flow to the duodenum increased linearly with increasing CP level from 8 to 16%, whereas N retention (% of N intake) was maximized at 12% CP on the previous study. It appears that methionine was the first limiting amino acid since flow of methionine had the lowest increase per unit of increase in dietary CP level. However, the actual requirement for methionine appears to be low since total flow of methionine (and DAPA) to the duodenum did not exceed 2 g/d on the 16% CP diet. It is inappropriate, however, to make an estimate of the methionine requirement from these experiments since they were conducted under different conditions and with different animals.

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Table 1. Dietary ingredients and chemical composition of diets fed to wethers

Ingredient	Protein level, %				
	8	10	12	14	16
-----% dry matter basis-----					
AHPWS ^a	65.9	65.9	65.8	65.8	65.7
Ground corn	24.4	18.7	13.1	7.5	2.0
Soybean meal	7.4	13.2	18.9	24.6	30.3
Dicalcium phosphate	.9	.8	.7	.6	.5
Calcium carbonate	.4	.4	.5	.5	.5
Potassium chloride	.6	.6	.6	.6	.6
Trace mineral salt ^b	.3	.3	.3	.3	.3
Vitamin premix ^c	.1	.1	.1	.1	.1
Chemical composition					
Dry matter	66.1	66.2	66.2	66.3	66.3
Organic matter	86.1	85.7	85.4	85.1	84.7
Neutral detergent fiber	47.9	47.6	47.3	47.0	46.8
Acid detergent fiber	33.2	33.2	33.2	33.2	33.2
Nitrogen	1.34	1.76	2.18	2.60	3.01

^aAHPWS = alkaline hydrogen peroxide-treated wheat straw.

^bComposition: NaCl = 93 to 98%; Zn = .35%; Fe = .34%; Mn = .20%; Cu = .033%; I = .007%; Se = .0055%; and Co = .005%.

^cComposition: vitamin A = 681,818 IU/kg; vitamin D = 68,182 IU/kg; vitamin E = 455 IU/kg; vitamin B-12 = 3.6 mg/kg; riboflavin = 227 mg/kg; D-pantothenic acid = 1,250 mg/kg; niacin = 3,409 mg/kg; and choline chloride = 34,091 mg/kg.

Table 2. Organic matter (OM) digestion by lambs fed increasing dietary crude protein

Item	Protein level, %					SE
	8	10	12	14	16	
	-----g/d-----					
OM intake ^a	720	718	715	712	709	.1
OM flow at duodenum	398	392	347	369	373	19.7
OM flow at ileum ^b	292	255	244	255	232	16.4
Fecal OM excretion ^c	210	199	186	198	192	5.4
OM digestion, % of OM intake						
stomach _A ^d	44.8	45.4	51.4	48.2	47.7	2.56
stomach _T ^{b,d}	66.5	67.2	72.2	72.8	73.6	2.03
intestine	14.6	19.2	14.2	16.1	19.7	2.32
hindgut ^c	11.4	7.8	8.3	7.9	5.7	1.88
total tract ^c	70.8	72.3	73.9	72.2	73.1	.74

^aLinear effect due to increasing protein level ($P < .01$).

^bLinear effect due to increasing protein level ($P < .05$).

^cLinear effect due to increasing protein level ($P < .10$).

^dStomach_A and Stomach_T = apparent and true digestion in the stomach, respectively.

Table 3. Neutral detergent fiber (NDF) digestion by lambs fed increasing dietary crude protein

Item	Protein level, %					SE
	8	10	12	14	16	
NDF intake, g/d ^a	396	394	392	394	391	23.3
NDF digestion, % of NDF intake						
stomach ^b	62.8	62.0	67.7	67.5	67.8	1.85
intestine	-3.6	4.3	0.3	-0.1	2.6	1.87
hindgut ^b	11.6	6.1	7.0	5.5	4.6	1.62
total tract ^b	70.8	72.4	75.0	72.8	75.0	1.17

^aLinear effect due to increasing dietary protein level ($P < .01$).

^bLinear effect due to increasing dietary protein level ($P < .05$).

Table 4. Nitrogen (N) digestion by lambs fed increasing levels of dietary crude protein

Item	Protein level, %					SE
	8	10	12	14	16	
	-----g/d-----					
N intake ^a	11.3	14.7	18.2	21.7	25.2	.15
Duodenal N flow						
Total ^a	17.7	18.6	19.9	22.3	24.2	1.12
Bacterial ^a	14.1	14.1	13.4	15.8	16.6	.60
Ileal N flow	7.1	7.0	7.4	7.9	7.3	.49
Fecal N flow	6.2	5.9	5.9	6.3	6.2	.17
Nonbacterial-N at duodenum, % of N intake	29.2	30.0	36.0	30.0	29.9	3.21
N digestion, % of N entering						
small intestine ^b	59.8	62.7	63.0	64.3	69.0	2.65
hindgut	10.0	13.8	18.1	19.5	15.4	4.61
total tract ^{c,d} _A	45.3	59.6	67.4	71.1	75.6	.86
Bacterial N synthesis						
g/100 g OMD _A ^e	4.41	4.44	3.67	4.69	5.09	.476
g/100 g OMD _T ^e	2.94	2.95	2.61	3.06	3.21	.195

^aLinear effect due to increasing CP level (P < .01).^bLinear effect due to increasing CP level (P < .05).^cPositive quadratic effect due to increasing CP level (P < .01).^dTotal tract_A = apparent total tract.^eOMD_A = organic matter apparently digested in the rumen; OMD_T = organic matter truly digested in the rumen.

Table 5. Effects of increasing dietary crude protein level on ruminal ammonia-N concentrations

Hour post-feeding	Protein level, %					SE
	8	10	12	14	16	
2 ^a	1.8	5.4	8.5	8.6	13.7	1.83
4 ^a	1.6	2.8	7.5	6.8	10.5	.93
6 ^a	1.1	5.2	7.7	9.2	11.5	.84
8 ^a	2.3	8.5	9.9	11.9	13.3	.81
10 ^a	4.8	10.3	10.8	13.8	14.5	1.35
12 ^a	7.3	10.5	10.3	12.9	13.2	.79
Average ^b	3.3	7.1	9.5	10.5	12.8	.47

^aLinear effect of increasing protein level ($P < .01$).

^bPositive quadratic effect of increasing protein level ($P < .01$).

Table 6. Duodenal flows of amino acids (AA) in lambs fed increasing levels of dietary crude protein

Item	Protein level, %					SE
	8	10	12	14	16	
	-----g/d-----					
Total flows						
Threonine ^a	4.6	5.1	6.7	7.0	8.6	.87
Valine ^a	5.0	5.4	7.2	7.7	9.7	.10
Methionine ^b	1.2	1.3	1.6	1.7	1.9	.21
Isoleucine ^a	4.3	4.8	6.2	6.6	8.3	.85
Leucine ^b	7.8	8.5	10.8	11.2	13.4	1.40
Phenylalanine ^a	3.8	4.4	5.5	5.9	7.3	.73
Histidine ^a	1.8	2.0	2.6	2.8	3.4	.19
Lysine ^a	6.0	7.1	9.0	9.5	12.0	.74
Arginine ^a	3.3	3.8	4.9	5.5	6.9	.38
Total flows ^a	79.1	88.6	112.3	118.4	145.1	14.83
EAA ^{a,c}	37.8	42.5	54.6	57.9	71.5	7.45
NEAA ^{a,d}	41.3	46.1	57.7	60.5	73.5	7.38
Bacterial						
Total AA ^a	85.0	85.1	80.9	95.1	100.2	3.61
EAA ^a	42.2	42.2	40.2	47.2	49.7	1.79
NEAA ^a	42.8	42.9	40.7	47.9	50.5	1.82
Nonbacterial ^e						
Total AA ^b	-5.9	3.5	31.4	23.3	44.9	13.56
EAA ^b	-4.4	.3	14.4	10.7	21.8	6.80
NEAA ^b	-1.5	3.2	17.0	12.6	23.1	6.77

^aLinear effect with increasing protein level ($P < .01$).

^bLinear effect with increasing protein level ($P < .05$).

^cEAA = essential amino acids (THR+VAL+MET+ILE+LEU+PHE+HIS+LYS+ARG).

^dNEAA = nonessential amino acids (ASP+SER+GLU+PRO+GLY+ALA+TYR).

^eNonbacterial amino acids include dietary escape, endogenous and possibly some protozoal amino acids.

Table 7. Profiles of amino acids (AA) flowing to the duodenum of lambs fed increasing levels of crude protein

Amino acid	Protein level, %					SE
	8	10	12	14	16	
	-----g/100 g AA-----					
Threonine	5.8	5.8	6.0	5.9	5.9	.04
Valine ^a	6.3	6.2	6.5	6.5	6.7	.07
Methionine ^b	1.5	1.5	1.4	1.4	1.3	.07
Isoleucine ^a	5.4	5.4	5.5	5.6	5.7	.04
Leucine	9.8	9.5	9.6	9.4	9.3	.18
Phenylalanine ^b	4.8	5.0	4.9	5.0	5.0	.05
Histidine	2.3	2.3	2.3	2.4	2.4	.04
Lysine ^b	7.6	7.9	8.0	8.0	8.2	.18
Arginine ^a	4.2	4.4	4.4	4.7	4.8	.07
Aspartic acid ^a	11.8	11.7	12.2	12.2	12.2	.06
Serine	5.0	4.8	4.9	4.9	4.9	.10
Glutamic acid ^a	14.5	14.3	14.2	14.1	13.8	.10
Proline ^a	4.8	4.8	4.6	4.5	4.4	.05
Glycine	5.4	5.3	5.2	5.2	5.3	.07
Alanine ^a	6.9	6.9	6.6	6.5	6.5	.08
Tyrosine	3.8	4.1	3.5	3.6	3.6	.19

^aLinear effect of increasing protein level ($P < .01$).

^bLinear effect of increasing protein level ($P < .05$).

Table 8. Net disappearance of amino acids (AA) from the small intestine of lambs fed increasing levels of crude protein

Item	Protein level, %					SE
	8	10	12	14	16	
	-----g/d-----					
Threonine ^a	1.9	1.9	3.7	3.8	5.7	.88
Valine ^a	2.3	2.4	4.2	4.5	6.7	.97
Methionine ^b	.3	.3	.7	.9	1.1	.24
Isoleucine ^a	2.4	2.6	4.0	4.3	6.1	.82
Leucine ^a	3.0	3.4	5.9	6.4	9.0	1.42
Phenylalanine ^a	2.1	2.4	3.5	3.7	5.4	.70
Histidine ^a	.7	.80	1.5	1.6	2.3	.19
Lysine ^a	3.4	4.2	6.1	6.6	9.3	.73
Arginine ^a	2.1	2.3	3.5	4.1	5.7	.38
Total AA ^a	36.0	40.0	65.8	70.6	100.8	14.78
EAA ^{a,c}	18.0	20.3	33.1	35.9	51.3	7.33
NEAA ^{a,d}	17.9	19.8	32.7	34.7	49.4	7.48
Disappearance, % of AA entering duodenum						
Total AA ^b	45.7	48.6	57.1	58.7	67.6	6.49
EAA ^b	48.0	50.8	59.4	61.2	70.0	6.14
NEAA ^b	43.5	46.5	55.0	56.4	65.2	6.82

^aLinear effect of increasing protein level ($P < .01$).

^bLinear effect of increasing protein level ($P < .05$).

^cEAA = essential amino acids (THR + VAL + MET + ILE + LEU + PHE + HIS + LYS + ARG).

^dNEAA = nonessential amino acids (ASP + SER + GLU + PRO + GLY + ALA + TYR).

EFFECTS OF SUPPLEMENTAL PROTEIN SOURCE AND LEVEL OF UREA ON INTESTINAL AMINO ACID SUPPLY IN LAMBS FED ALKALINE HYDROGEN PEROXIDE-TREATED WHEAT STRAW-BASED DIETS

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SUMMARY

A 5 x 5 Latin square experiment was conducted with five cannulated (ruminal, duodenal and ileal) Suffolk-cross wethers (61 kg) to determine the effects of different protein sources and level of supplemental urea on intestinal supply of nitrogen (N) and amino acids (AA) in animals fed alkaline hydrogen peroxide-treated wheat straw (AHPWS)-based diets. Treatments were soybean meal (SBM), a combination of urea, distillers dried grains (DDG) and fish meal with each crude protein (CP) source providing an equal portion of supplemental CP (UDF), and three levels of urea (17, 33 and 50% of supplemental CP) fed in combination with DDG (U17, U33 and U50). Organic matter (OM) and N digestibilities were decreased ($P < .05$) in lambs fed U17. Duodenal N and AA flows were greatest ($P < .05$) for U17 and UDF compared to other CP sources. There were no differences ($P > .05$) in bacterial N or AA flows to the duodenum due to supplemental CP source despite large differences in ruminal ammonia-N concentrations and lower ruminal OM digestion in lambs fed U17. Duodenal nonbacterial N and AA flows were highest ($P < .05$) in lambs fed U17 and UDF and lowest in lambs fed U50 and SBM. Lysine content of duodenal digesta decreased in relation to other AA with each incremental increase in DDG. Data are interpreted to indicate that no more than 33% of supplemental CP should originate from urea in AHPWS-based diets. Seventeen percent urea appears adequate to maximize bacterial protein synthesis. Feeding a combination of ruminally resistant protein sources with complementary AA profiles of lysine and methionine (UDF) may enhance the quality of protein entering the duodenum.

INTRODUCTION

Urea is a common source of supplemental crude protein (CP) in ruminant diets. Although urea has been used for many years, there is considerable debate concerning conditions and levels that promote optimal use. Urea has value to the ruminant animal only when it is converted to microbial protein. Energy level and type of diet (roughage vs concentrate) are major determinants of effective urea usage. Also, dietary protein level and ruminal degradability of other dietary protein sources influence urea utilization.

Burroughs et al. (1972) suggested that low protein, highly fermentable feedstuffs ($> 75\%$ TDN) have the greatest potential for being supplemented with urea. Alkaline hydrogen peroxide-treated wheat straw (AHPWS) is a high fiber (65% NDF), highly fermentable (70% dry matter digestibility), low protein (1-3% CP) feedstuff. Urea supplementation could be advantageous in AHPWS-based diets since AHPWS has these characteristics. A feasible

approach to minimizing supplemental CP cost is to optimize combinations of urea and ruminally resistant protein sources such as distillers dried grains (DDG) and fish meal. Distillers dried grains improved cattle performance when included in corn cob based-diets that had little true protein in basal ingredients (Waller et al., 1980). Cecava et al. (1990) demonstrated the complementary effects of corn gluten meal (rich methionine source) and blood meal (rich lysine source) on the profile of amino acids (AA) entering the small intestine. Similar results may be achieved with DDG (high methionine) and fish meal (high lysine).

The objectives of this trial were to determine the effects of level of urea supplementation and different sources of supplemental protein on intestinal AA supply and site and extent of nutrient digestion.

PROCEDURES

A 5 x 5 Latin square design was used to allot five cannulated (ruminal, duodenal and ileal) Suffolk-cross wethers (61 kg) to five supplemental protein treatments. Treatments were soybean meal (SBM), a combination of urea, DDG and fish meal in which each protein source provided equal portions of supplemental protein (UDF), and three levels of urea fed in combination with DDG and corn. Levels of urea and DDG (% of supplemental CP basis) were 17% urea:83% DDG (U17), 33% urea:67% DDG (U33) and 50% urea:50% DDG (U50). All diets were 65% AHPWS:35% concentrate and formulated to contain 12.5% CP (Table 1). However, due to differences in N content of fish meal compared with that analyzed prior to initiation of the trial, and(or) sampling and mixing errors, the UDF diet was higher in CP than expected. The fish meal-containing diet was expected to be the least acceptable. Therefore, a pretrial period was conducted to determine ad libitum intake on this diet. All lambs were fed two times daily at 12 h intervals at 90% ad libitum of the lamb consuming the least feed. At time of feeding, wethers were dosed with 1.5 g chromic oxide (3.0 g/d) so that sites of nutrient digestion and intestinal flows of AA could be quantified.

Each 16 d period consisted of 10 d for diet adaptation and 6 d for sample collection. Feed, duodenal and ileal digesta samples and feces were collected on d 11-16. On odd and even numbered days during the collection phase, duodenal (100 ml) and ileal (50 ml) samples were collected at 2, 6 and 10 h and 4, 8 and 12 h post-AM feeding, respectively, such that a total of 18 samples were collected and composited by animal each period. Samples were dried at 55 C (feed and feces) or freeze dried (duodenal and ileal digesta) and ground through a 1 mm screen using a Wiley mill. All samples were analyzed for dry matter, organic matter (OM) and nitrogen (N). Ruminal contents (250 ml) were collected once daily, such that each of the above hours post AM feeding were represented, to obtain a bacteria-rich fraction. Ruminal contents were homogenized with an equal volume of saline for 30 sec, strained through 4 layers of cheesecloth and frozen. Subsequently, composited samples were thawed and bacteria isolated by differential centrifugation. Concentrations of AA were determined for duodenal, ileal and bacterial samples. Duodenal flows of N and AA of bacterial and nonbacterial origin were calculated using

purines as a bacterial marker. On the last day of each period, ruminal contents (50 ml) were collected at 3, 6 and 9 h post AM-feeding and pH immediately determined. Ruminal samples were acidified with 6N HCl, frozen and subsequently analyzed for ruminal ammonia-N and volatile fatty acid concentrations.

Data were analyzed as a 5 x 5 Latin square design using GLM procedures of SAS. Terms in the model were period, animal and protein source. Treatment mean differences for effects of protein source were separated using the LSD method only when protected by a significant F-test ($P < .05$). There was one missing observation due to the death of one animal. Data collected at various times post-feeding (ruminal pH, ammonia-N and volatile fatty acid concentrations) were analyzed as separate Latin squares for each time and the average across time was analyzed as a separate square.

RESULTS AND DISCUSSION

Organic matter apparently and truly digested in the rumen increased from 41.5 and 63.6% of OM intake on the U17 diet to 50.4 and 71.5% of OM intake on the SBM diet, respectively (Table 2). True ruminal OM digestion in lambs fed U17 tended ($P < .09$) to be lower than in lambs fed U33 and UDF. Wethers fed U50 tended ($P < .06$) to have lower true ruminal OM digestion than wethers fed SBM. Small intestinal and hindgut digestion were unaffected by protein treatment. Small intestinal OM digestion ranged from 12.1% to 16.8% of OM intake on the U17 and SBM diets, respectively, while hindgut OM fermentation ranged from 7.6 to 13.7% of OM intake on U33 and U50 diets, respectively. Total tract digestibility was lowest ($P < .05$) on the U17 diet compared to all other treatments. There were no differences in total tract OM digestibility among all other treatments.

Ruminal characteristics reflect the differences in OM digestion. Total volatile fatty acid (TVFA) and acetate concentrations (mM) were lower ($P < .05$) in lambs fed U17 compared to all other treatments (Table 3). Lambs fed SBM had higher ($P < .05$) TVFA and acetate concentrations than lambs fed U33. Ruminal TVFA and acetate concentrations were intermediate for lambs fed U50 and UDF. There were no differences in propionate concentration among protein treatments, but the percent propionate was highest and the acetate:propionate ratio lowest in wethers fed the U17 diet. Soybean meal-fed lambs had higher valerate and isovalerate concentrations compared to all other treatments. Ruminal pH was greater than 6.0 for all treatments and likely had no effect on digestion kinetics. Differences in pH are reflective of the differences in TVFA concentrations. Increases in OM digestion increased TVFA concentration and lowered pH.

These differences in OM digestion and ruminal characteristics can be related in part to differences in ruminal degradability of DDG and SBM. There were approximately 18 percentage units difference in ruminal escape of dietary CP from the concentrate portion of the diets (nonbacterial N as a percent of N intake, excluding N from urea and AHPWS) between U17- and SBM-fed lambs in this study (Table 4). The concentrates represent approximately 505 g of OM intake (1530 g OM intake x 33% concentrate, excluding

minerals). Assuming a similar difference in OM digestion, this difference in ruminal degradability accounts for 90 g nondigested OM (505 g x 18%). Lambs supplemented with SBM digested 136 g more OM in the rumen than those fed U17.

Nitrogen intake was affected by supplemental CP source which may confound some of the results (Table 4). Diets were formulated to be isonitrogenous but variability in dietary ingredients from initial analysis, and(or) sampling and mixing errors, precluded N intake being similar across all treatments. Total N flow to the duodenum ranged from 38.0 to 45.6 g/d for the U50 and UDF diets, respectively. There were no differences in bacterial N entering the duodenum despite large differences in ruminal ammonia-N concentrations (Table 5). At 3 h post-feeding, lambs fed U50 had a ruminal ammonia-N concentration of 26.2 mg/dl, while lambs fed SBM, U33 and UDF had ammonia-N concentrations ranging from 5.2 to 11.9 mg/dl. At none of the sampling times (3, 6 and 9 h post-feeding) did lambs fed U17 have ammonia-N concentrations greater than 3.0, yet bacterial N flow was similar to that for other treatments. Wethers fed SBM had a higher ($P < .05$) ruminal ammonia-N concentration at 9 h post-feeding than lambs fed the other treatments, indicating greater N recycling. There were no differences ($P > .05$) in efficiency of bacterial CP synthesis expressed either as g per 100 g apparently or truly digested in the rumen (Table 4). However, lambs fed U17 had similar bacterial N flow to the duodenum despite lower ruminal OM digestion due to a nonsignificant increase in efficiency of bacterial protein synthesis. These data are interpreted to indicate that urea-N was not efficiently incorporated (in relation to amount fed) into microbial protein when 50% of the supplemental protein was provided by urea. Urea supplied sufficient ruminal ammonia-N to maximize postruminal supply of bacterial protein when fed at 17 or 33% of the supplemental protein. Soybean meal supplemented lambs had numerically higher bacterial N flow entering the duodenum than U17-, U33- and U50-fed lambs. Other studies have shown numerically higher bacterial N flow when SBM was the supplemental protein source vs urea. This could be due to SBM being highly degradable in the rumen and increasing the supply of AA and(or) peptides to bacteria. Several studies have been conducted with urea providing 33 to 40% of the supplemental CP to ensure adequate ruminal ammonia-N levels to maximize bacterial protein synthesis. In AHPWS-based diets fed to lambs, approximately one-half this amount appears to be adequate.

Since there were no differences in bacterial N flow among protein treatments, differences in total N flow are due primarily to differences in nonbacterial N (NBN) flow (Table 4), although increased N intake could account for some of the increased NBN in UDF fed lambs. Nevertheless, lambs fed U17 had similar amounts of NBN entering the duodenum than lambs fed UDF even though UDF-fed lambs had higher N intake. Nonbacterial N flow was lowest for U50 and SBM diets and highest for U17 and UDF diets. Low NBN flow in lambs fed U50 and SBM is due to decreased dietary true protein and the high ruminal degradability of SBM, respectively. Nonbacterial N flow tended ($P < .10$) to be higher on U33 and was increased ($P < .05$) on U17 and UDF diets compared to SBM. Thus, decreased ruminal degradability of DDG, corn and fish meal vs SBM more than offset the dilution of true protein in the diet due to inclusion of urea. Corn, DDG and fish meal are relatively resistant to ruminal degradation as evidenced by ruminal escape N (NBN, nonurea, non-AHPWS-N intake). Ruminal escape N was lower ($P < .05$) in lambs

fed SBM compared to lambs fed U17, U33 and UDF and tended ($P < .10$) lower than lambs fed U50.

Nitrogen digestion in the small intestine (Table 4) was similar for lambs fed the urea-containing diets. Lambs fed SBM had greater ($P < .05$) small intestinal N digestion than lambs fed U17, U50 and UDF and tended ($P < .10$) to have higher N digestion than U33. There were no differences in digestion of N-containing compounds in the hindgut. Total tract N digestion was lower ($P < .05$) for lambs fed U17 compared to all other treatments.

Flows of AA entering the duodenum are presented in Table 6. Lambs fed UDF had higher ($P < .05$) duodenal flows of threonine, histidine and arginine than lambs fed other supplemental CP sources. Lambs fed U17 had more ($P < .05$) leucine entering the duodenum. Lysine flow was greatest ($P < .05$) in lambs fed SBM and UDF compared to other diets. There were no significant differences in duodenal methionine flow although lambs fed SBM and UDF had numerically the lowest and highest methionine flow, respectively. Total flows of essential and nonessential AA to the duodenum were lowest for wethers fed U50 and highest for wethers fed UDF. Total, essential and nonessential duodenal AA flows were similar ($P > .05$) for lambs fed U50 and SBM and for lambs fed U17 and UDF. In general, as urea level increased, total, essential and nonessential AA flows decreased. There were no differences in flows of AA from bacterial origin. However, wethers fed SBM and UDF had numerically higher flows of bacterial AA to the duodenum than U17, U33- and U50-fed wethers. Nonbacterial essential and nonessential AA flows were numerically highest for lambs fed U17. Lambs fed U17, U33 and UDF had higher ($P < .05$) nonbacterial AA flows than lambs fed SBM or U50. Nonbacterial essential and nonessential AA flows tended ($P < .10$) to be higher in lambs fed U17 than in lambs fed U33.

Proportion of each AA (g/100 g total AA) entering the duodenum, except methionine, was affected by supplemental protein source (Table 7). Duodenal threonine and isoleucine content in relation to other AA was highest ($P < .05$) in lambs fed SBM. Lambs fed U17 had the highest ($P < .05$) concentration of leucine, glutamic acid and proline. Lambs fed UDF had the lowest ($P < .05$) phenylalanine and highest ($P < .05$) glycine concentration in relation to other AA entering the duodenum. Lysine content in relation to other AA decreased ($P < .05$), and methionine content numerically increased, with each incremental increase in DDG and corn (U50 to U33 to U17). Lambs fed SBM had the highest ($P < .05$) lysine content and numerically the lowest methionine content compared to other supplemental crude protein sources. Lambs fed UDF had a higher proportion ($P < .05$) of lysine than lambs fed U17 and U33, but a lower ($P < .05$) proportion than lambs fed SBM. While maintaining a relatively high proportion of lysine, lambs fed UDF had numerically the highest methionine content. Methionine and lysine have been implicated as limiting AA for ruminants when predominantly bacterial protein enters the duodenum. Manipulating the profile of AA entering the small intestine by use of escape protein may enhance the biological value of protein entering the duodenum. Fish meal is a rich source of lysine and DDG is a rich source of methionine. Cecava et al. (1990) reported similar results in AHPWS-based diets with corn gluten meal and blood meal combinations.

There were no differences ($P > .05$) in net disappearance of total, essential and nonessential AA in the small intestine, although there were differences in disappearance among individual essential AA (Table 8). Total, essential and nonessential AA disappearance from the small intestine was numerically lowest in lambs fed U50 and highest in lambs fed UDF. This is consistent with other reports where disappearance of AA increased as the quantity of AA entering increased. However, net disappearance of total and nonessential AA expressed as a percentage of AA entering was lower ($P < .05$) in lambs fed U17, U50 and UDF than in lambs fed SBM. This indicates that SBM protein that escapes ruminal degradation is more digestible than that of DDG.

In conclusion, these data are interpreted to indicate that no more than 33% of supplemental CP should be derived from urea in AHPWS-based diets. Feeding higher levels of urea decreased total and nonbacterial AA flow to the duodenum. As little as 17% supplemental CP protein from urea was adequate to maximize bacterial protein synthesis. Feeding a high level of DDG (e.g., U17 diet) can lead to decreased OM, N and AA digestion. Supplementing diets with a combination of ruminally resistant protein sources with complementary AA profiles may improve the quality of protein entering the small intestine. In particular, lambs fed UDF had a higher concentration of lysine than lambs fed urea in combination with DDG and a nonsignificant increase in methionine profile compared to SBM fed lambs.

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Table 1. Dietary ingredients and chemical composition of diets fed to wethers

Ingredient	Protein source ^a				
	SBM	U17	U33	U50	UDF
AHPWS ^b	63.8	64.3	64.3	64.3	64.1
Corn	18.6	3.0	10.8	18.6	18.1
Soybean meal	15.8				
Distillers dried grains		30.5	21.9	13.3	10.2
Fish meal					5.5
Urea		.6	1.2	1.8	1.2
Dicalcium phosphate	.5	.2	.4	.6	
Calcium sulfate ^c			+	+	.1
Calcium carbonate	.5	.6	.6	.6	
Trace mineralized salt ^d	.3	.3	.3	.3	.3
Potassium chloride	.3	.3	.3	.3	.3
Vitamin premix ^e	.2	.2	.2	.2	.2
Chemical Composition					
Dry matter	66.9	66.4	66.4	66.4	66.6
Organic matter	87.3	87.3	87.6	87.8	88.0
Neutral detergent fiber	47.4	55.9	55.1	53.0	52.4
Acid detergent fiber	30.9	34.1	33.4	32.1	31.8
Nitrogen	1.9	2.0	2.0	2.1	2.4

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^bAHPWS = alkaline hydrogen peroxide-treated wheat straw.

^cCalcium sulfate content was .02% and .05% in the U17 and U33 diets, respectively. Calcium sulfate was added to obtain a N:sulfur ratio of 10:1.

^dComposition: NaCl = 93 to 98%; Zn = .35%; Fe = .34%; Mn = .20%; Cu = .033%; I = .007%; Se = .0055%; and Co = .005%.

^eComposition: vitamin A = 681,818 IU/kg; vitamin D = 68,182 IU/kg; vitamin E = 455 IU/kg; vitamin B-12 = 3.6 mg/kg; riboflavin = 227 mg/kg; D-pantothenic acid = 1,250 mg/kg; niacin = 3,409 mg/kg; and choline chloride = 34,091 mg/kg.

Table 2. Organic matter (OM) digestion by lambs fed different sources of supplemental dietary crude protein

Item	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
	-----g/d-----					
OM intake	1533	1533	1530	1513	1525	12.5
OM flow at duodenum	761	897	804	817	839	29.6
OM flow at ileum	504 ^b	711 ^d	548 ^{b,c}	621 ^c	604 ^c	23.8
Fecal OM excretion	404 ^b	537 ^c	433 ^b	413 ^b	416 ^b	30.6
OM digestion, % of OM intake						
stomach _A ^e	50.4 ^d	41.5 ^b	47.5 ^{c,d}	46.1 ^{b,c,d}	45.0 ^{b,c}	1.77
stomach _T ^e	71.5 ^c	63.6 ^b	67.9 ^{b,c}	67.1 ^{b,c}	67.4 ^{b,c}	1.47
small intestine	16.8	12.1	16.7	12.9	15.5	1.68
hindgut	6.5	11.4	7.6	13.7	12.3	2.27
total tract	73.7 ^c	65.0 ^b	71.7 ^c	72.8 ^c	72.7 ^c	1.95

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d}Means in the same row with different superscript letters differ ($P < .05$).

^eStomach_A and stomach_T = OM apparently and truly digested in the stomach, respectively.

Table 3. Effects of different sources of supplemental dietary crude protein on ruminal volatile fatty acid concentrations and molar percentages and pH

Item	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
Total VFA, mM ^e	106.3 ^d	84.8 ^b	94.8 ^c	100.6 ^{c,d}	100.5 ^{c,d}	2.80
Acetate, mM	72.7 ^d	55.4 ^b	63.9 ^c	66.6 ^c	68.4 ^{c,d}	1.95
Propionate, mM	19.3	18.6	18.5	21.0	19.9	.84
Butyrate, mM	11.3	9.0	10.2	11.0	10.0	.62
Isobutyrate, mM	.8	.4	.7	.3	.5	.13
Isovalerate, mM	1.4 ^c	.9 ^b	.9 ^b	1.0 ^b	1.1 ^b	.08
Valerate, mM	.8 ^c	.6 ^b	.5 ^b	.6 ^b	.6 ^b	.04
Acetate, %	68.3 ^c	65.4 ^b	67.6 ^{b,c}	66.3 ^{b,c}	68.2 ^c	.83
Propionate, %	18.1 ^b	21.7 ^d	19.4 ^{b,c}	20.8 ^{c,d}	19.7 ^{b,c}	.62
Butyrate, %	10.7	10.6	10.7	10.9	9.9	.17
Acetate:propionate	3.8 ^c	3.1 ^b	3.5 ^{b,c}	3.2 ^b	3.5 ^{b,c}	.14
pH	6.3 ^b	6.6 ^d	6.5 ^{c,d}	6.5 ^{c,d}	6.4 ^c	.05

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d}Means in the same row with different superscript letters differ ($P < .05$).

^eTotal VFA = total volatile fatty acids (sum of acetate, propionate, butyrate, isobutyrate, isovalerate and valerate).

Table 4. Nitrogen (N) digestion by lambs fed different sources of supplemental dietary crude protein

Item	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
	-----g/d-----					
N intake	33.2 ^b	34.6 ^c	35.6 ^c	36.9 ^d	41.5 ^e	.30
Duodenal N flow						
total	41.1 ^c	43.4 ^{c,d}	42.0 ^c	38.0 ^b	45.6 ^d	.89
bacterial	32.5	31.4	30.8	30.8	33.7	1.02
nonbacterial	8.6 ^{b,c}	12.0 ^d	11.2 ^{c,d}	7.2 ^b	11.9 ^d	.90
Ileal N flow	14.1 ^b	19.4 ^d	16.7 ^c	16.5 ^c	19.0 ^{c,d}	.73
Fecal N excretion	12.1 ^b	17.0 ^c	14.5 ^{b,c}	12.8 ^b	14.2 ^b	.83
Nonbacterial N at duodenum, % of NUNWS-N intake ^f	29.8 ^b	47.2 ^{c,d}	52.6 ^d	39.9 ^{b,c}	43.4 ^{c,d}	3.72
N digestion, % of N entering						
small intestine	65.6 ^c	55.4 ^b	60.2 ^{b,c}	56.5 ^b	58.4 ^b	1.71
hindgut	13.5	10.4	11.7	21.2	24.6	6.16
total tract	63.5 ^c	51.0 ^b	59.3 ^c	65.3 ^c	65.7 ^c	2.24
Bacterial N synthesis						
g/100 g OMD _A ^g	4.26	5.13	4.30	4.48	4.95	.347
g/100 g OMD _T ^g	2.98	3.25	2.96	3.04	3.38	.134

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d,e}Means in the same row with different superscript letters differ ($P < .05$).

^fNUNWS-N = nonurea, nonalkaline hydrogen peroxide-treated wheat straw-nitrogen.

^gOMD_A = organic matter apparently digested in the rumen; OMD_T = organic matter truly digested in the rumen.

Table 5. Effects of different sources of supplemental dietary crude protein on ruminal ammonia-N concentration

Hours post-feeding	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
	-----mg/dl-----					
3	5.2 ^{b,c}	2.9 ^b	9.8 ^{c,d}	26.2 ^e	11.9 ^d	1.43
6	6.9	.5	2.7	5.3	5.1	1.40
9	12.4 ^c	2.9 ^b	4.3 ^b	6.5 ^b	4.8 ^b	1.14
average	8.2 ^c	2.1 ^b	5.6 ^c	12.7 ^d	7.3 ^c	.86

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d,e}Means in the same row with different superscript letters differ ($P < .05$).

Table 6. Duodenal flows of amino acids (AA) in lambs fed different sources of supplemental dietary crude protein

Amino acid	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
	-----g/d-----					
Total flows						
Threonine	10.7 ^c	10.3 ^c	10.0 ^{b,c}	9.3 ^b	11.5 ^d	.27
Valine	11.8 ^{c,d}	12.3 ^{d,e}	11.2 ^{b,c}	10.4 ^b	13.3 ^e	.32
Methionine	2.3	2.7	2.8	2.9	3.2	.27
Isoleucine	10.4 ^{c,d}	10.2 ^{c,d}	9.7 ^{b,c}	8.9 ^b	11.1 ^d	.32
Leucine	17.3 ^b	22.4 ^d	20.3 ^c	17.7 ^b	20.8 ^{c,d}	.58
Phenylalanine	10.4 ^{b,c}	11.2 ^{c,d}	10.4 ^{b,c}	9.5 ^b	11.5 ^d	.30
Histidine	4.3 ^c	4.6 ^c	4.3 ^c	3.8 ^b	4.7 ^d	.11
Lysine	13.4 ^c	10.2 ^b	10.6 ^b	10.6 ^b	13.6 ^c	.40
Arginine	9.6 ^d	8.9 ^{c,d}	8.5 ^{b,c}	7.7 ^b	10.8 ^e	.30
Total flows	193.3 ^{b,c}	206.9 ^{c,d}	195.4 ^{b,c}	178.0 ^b	222.0 ^d	5.62
Essential AA ^f	90.1 ^c	92.7 ^{c,d}	87.8 ^{b,c}	80.8 ^b	100.5 ^d	2.69
Nonessential AA ^g	103.2 ^{b,c}	114.2 ^d	107.6 ^{c,d}	97.2 ^b	121.5 ^d	2.97
Bacterial						
Total AA	156.9	143.1	145.7	143.2	161.1	5.81
Essential AA	74.8	67.5	69.3	68.2	76.5	2.77
Nonessential AA	82.1	75.6	76.4	75.0	84.6	3.06
Nonbacterial ^h						
Total AA	36.4 ^b	63.8 ^c	49.7 ^{b,c}	34.8 ^b	60.9 ^c	4.82
Essential AA	15.3 ^b	25.2 ^c	18.5 ^{b,c}	12.6 ^b	24.0 ^c	2.22
Nonessential AA	21.1 ^b	38.6 ^c	31.2 ^c	22.2 ^b	36.9 ^c	2.62

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d,e}Means in the same row with different superscript letters differ ($P < .05$).

^fEssential AA = (THR + VAL + MET + ILE + LEU + PHE + HIS + LYS + ARG).

^gNonessential AA = (ASP + SER + GLU + PRO + GLY + ALA + TYR).

^hThis fraction contains dietary escape, endogenous and possibly some protozoal AA.

Table 7. Profile of amino acids (AA) entering the duodenum of lambs fed different sources of supplemental dietary crude protein

Amino acid	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
	-----g/100 g AA-----					
Threonine	5.5 ^e	5.0 ^b	5.1 ^c	5.2 ^d	5.2 ^{c,d}	.04
Valine	6.1 ^d	6.0 ^{c,d}	5.7 ^b	5.9 ^{b,c}	6.0 ^{c,d}	.07
Methionine	1.2	1.3	1.4	1.6	1.5	.10
Isoleucine	5.4 ^c	4.9 ^b	5.0 ^b	5.0 ^b	5.0 ^b	.05
Leucine	8.9 ^b	10.8 ^f	10.4 ^e	9.9 ^d	9.4 ^c	.08
Phenylalanine	5.4 ^c	5.4 ^c	5.3 ^c	5.3 ^c	5.2 ^b	.03
Histidine	2.3 ^d	2.2 ^{c,d}	2.2 ^{b,c}	2.2 ^b	2.1 ^b	.02
Lysine	6.9 ^e	4.9 ^b	5.4 ^c	6.0 ^d	6.1 ^d	.09
Arginine	5.0 ^c	4.3 ^b	4.3 ^b	4.3 ^b	4.9 ^c	.03
Aspartic acid	11.6 ^e	9.9 ^b	10.2 ^c	10.5 ^d	10.6 ^d	.08
Serine	5.1 ^b	5.1 ^b	5.1 ^b	5.1 ^b	5.3 ^c	.05
Glutamic acid	14.8 ^b	16.7 ^e	16.2 ^d	15.7 ^c	15.1 ^b	.12
Proline	5.0 ^b	6.5 ^e	6.2 ^d	5.9 ^c	6.0 ^{c,d}	.07
Glycine	5.2 ^d	4.8 ^b	4.9 ^{b,c}	5.0 ^c	5.9 ^e	.04
Alanine	6.7 ^b	7.6 ^d	7.5 ^d	7.3 ^c	7.2 ^c	.05
Tyrosine	5.0 ^{b,c}	4.7 ^b	5.0 ^{b,c}	5.2 ^c	4.7 ^b	.11

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d,e,f}Means in the same row with different superscript letters differ ($P < .05$).

Table 8. Net disappearance of amino acids (AA) from the small intestine of lambs fed different sources of supplemental dietary crude protein

Amino acid	Protein source ^a					SE
	SBM	U17	U33	U50	UDF	
	-----g/d-----					
Threonine	6.7 ^d	5.5 ^{b,c}	5.8 ^{b,c}	5.0 ^b	6.5 ^{c,d}	.35
Valine	7.7	6.9	6.6	6.1	7.7	.41
Methionine	2.0	2.1	2.3	2.4	2.6	.32
Isoleucine	7.5 ^c	6.5 ^{b,c}	6.5 ^{b,c}	5.8 ^b	7.4 ^c	.36
Leucine	12.6 ^{b,c}	15.5 ^d	14.4 ^{c,d}	12.2 ^b	14.2 ^{c,d}	.62
Phenylalanine	7.4 ^c	7.3 ^c	7.1 ^{b,c}	6.1 ^b	7.6 ^c	.32
Histidine	3.1 ^d	2.6 ^{b,c}	2.6 ^{b,c}	2.3 ^b	2.9 ^{c,d}	.14
Lysine	9.9 ^c	6.1 ^b	7.0 ^b	6.9 ^b	9.0 ^c	.46
Arginine	7.5 ^c	6.1 ^b	6.1 ^b	5.2 ^b	7.8 ^c	.33
Total AA	132.9	124.6	126.0	109.2	138.2	6.50
Essential AA ^e	64.3	58.6	58.5	51.8	65.7	3.14
Nonessential AA ^f	68.6	66.0	67.5	57.4	72.5	3.38
Disappearance, % of AA entering duodenum						
Total AA	68.7 ^c	60.5 ^b	64.4 ^{b,c}	61.0 ^b	62.0 ^b	1.90
Essential AA	71.4	63.4	66.5	63.8	65.0	1.91
Nonessential AA	66.4 ^c	58.0 ^b	62.7 ^{b,c}	58.8 ^b	59.4 ^b	1.90

^aLevels (% of supplemental protein basis) and protein sources are: SBM = soybean meal; U17 = 17% urea and 83% distillers dried grains (DDG) and corn; U33 = 33% urea and 67% DDG and corn; U50 = 50% urea and 50% DDG and corn; and UDF = 33% each of urea, DDG and corn, and fish meal.

^{b,c,d}Means in the same row with different superscript letters differ ($P < .05$).

^eEssential AA = (THR+VAL+MET+ILE+LEU+PHE+HIS+LYS+ARG).

^fNonessential AA = (ASP+SER+GLU+PRO+GLY+ALA+TYR).

EFFECTS OF FEEDING ALKALINE HYDROGEN PEROXIDE-TREATED OAT
HULL-BASED AND RICE STRAW-BASED DIETS ON FEED INTAKE AND NUTRIENT
DIGESTIBILITY BY GROWING WETHERS

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Merchen

INTRODUCTION

Approximately 80 to 85% of the feed consumed by ruminants in their lifetime production cycle consists of forages and roughages. About 500 million tons of farm crop residues are produced each year in the U.S. (Walker and Kohler, 1981). Large quantities of by-products are grown in the central region of the U.S. where much of the nation's corn, soybeans and small cereal grains are produced. Oat hulls (OH) are a lignocellulosic by-product of the oat milling industry. Because of their low digestibility and crude protein content, OH have been used primarily as a carrier for other ingredients. In addition, OH are bulky (193 kilograms/cubic meter) and unacceptable to ruminants unless mixed with other ingredients. Another lignocellulosic residue is rice straw (RS), a by-product of the rice milling industry. Rice straw is comparatively low in lignin (4 to 5%) but is relatively high in silica (13 to 16%) and, together, have a depressing influence on digestibility (Garrett et al., 1979). In recent years, the development of treatment processes that are economical and which will improve the nutritive

value of lignocellulosics for ruminants has been the aim of many researchers. Chemical treatment of lignocellulosic feedstuffs should increase both nutrient availability (digestibility) and roughage acceptability (intake). Recent research has shown that treatment with alkaline hydrogen peroxide (AHP) increased susceptibility of plant structural carbohydrates (cellulose, hemicelluloses) to fiber-digesting microorganisms in the ruminant digestive tract (Kerley et al., 1987). A more recent study showed that pelleted AHP-OH increased daily DM intakes (by 2.36 kg), apparent digestibility (by 4.9%), and digestible dry matter intake (by 2.3 kg) by beef heifers when compared with dehydrated alfalfa pellets (Berger et al., 1989). Despite the large amounts of OH and RS available each year, feeding the untreated forms have resulted in low intakes and low digestibilities. This has limited their use as components of ruminant diets.

The primary objectives of this experiment were to: 1) determine the effects of varying treatment conditions in the preparation of AHP-OH on its subsequent nutrient intake and apparent digestibility when fed to sheep, and 2) determine the effects of AHP treatment of RS on the same criteria.

MATERIALS AND METHODS

Sixteen Dorset wethers with a mean body weight (BW) of 32 kg (range: 23 to 41 kg) were used in a feed intake and nutrient

digestibility experiment consisting of three 15-d periods. Each period had a 10-d adaptation phase and a 5-d fecal collection phase. Twelve lambs were used for the OH experiment. The wethers were randomly allotted to the OH diets at the beginning of each period such that each wether would not be fed the same OH diet during the experiment. Four wethers were assigned to the two RS diets and were used in a switchback design. During the collection phase, total feces were collected and a 15% aliquot of feces from each lamb was saved for further analyses. During the experiment, wethers were individually housed in elevated mesh bottom crates in a temperature controlled (23°C) room with constant fluorescent lighting and fed daily at 0700 and 1900.

All wethers were fed a complete mixed diet of 80% forage (F) and 20% concentrate (C) on a DM basis with 65% OH or RS and 15% alfalfa hay (AH) as the sources of forage (Table 1). The complete mixed diets were fed ad libitum, allowing for at least 10% orts. Water was available continually. Diets were balanced to meet the minimal nutrient requirements for growing lambs (NRC, 1975). Diets contained at least 14% CP, .45% Ca, .30% P, 1.20% K, .26% S, and .25% Cl. The concentrate portion of each diet consisted of soybean meal, ground shelled corn, minerals, and vitamins (Table 1). Ingredient and chemical composition of diets fed to the wethers are presented in Tables 1 and 2.

The AHP treated OH and RS required for the experiment was prepared using a 3041 Marion Batch Mixer (Marion Mixers, Inc., Marion, IA) in conjunction with a Toledo 8142 Digital Indicator (Toledo Scale, Westerville, OH) and load cell system. The Toledo 8142 was programmed to start and stop the appropriate motors and pumps which delivered the OH or RS, water, and chemical reagents to the batch mixer in weighed amounts for mixing. Hydrogen peroxide (H_2O_2), sodium hydroxide (NaOH), and water were pumped into the batch mixer and applied via three spray nozzles. Upon starting the mixing sequence, the system collected OH or RS with a belt conveyor from a forage wagon, conveyed it to the batch mixer, and weighed the allotted amount of roughage. Sodium hydroxide was added at the level of 5.0% of the DM of the roughage. Both the water and NaOH pumps were started and the solution was sprayed onto the roughage until the scale reached a set point. The pumps shut off automatically, and mixing continued for 3 minutes. Upon completion of the 3 minute mix, H_2O_2 was added at 2.0% of the DM (except for treatment 2 where only 1% H_2O_2 was used). Water and H_2O_2 were sprayed onto the byproduct until the scale reached the final set point, the pumps shut off, mixing continued for 3 minutes, and the end product was discharged into another forage wagon. Feedstuffs were stored in cardboard barrels in an unheated building.

The eight treatments were: 1) 65% AHP-OH (prepared to contain 17.9% moisture in the final product), 15% AH, 20% C; 2) same as treatment 1 except only 1% hydrogen peroxide was used; 3) same as

treatment 1 except AHP-OH were prepared to contain 36.0% moisture in the final product; 4) same as treatment 1 except AHP-OH were pelleted using a California pellet mill (pellets were approximately 15 mm long and 5 mm in diameter); 5) 65% untreated OH, 15% AH, 20% C; 6) same as treatment 1 except AHP-OH were commercially prepared in Cincinnati, OH; 7) 65% AHP-RS (prepared to contain 35.7% moisture in the final product), 15% AH, 20% C; 8) 65% untreated RS, 15% AH, 20% C.

Dry matter (DM) intakes were measured daily. Samples of feed andorts were collected on d-11 through 15 and saved for analyses. Samples were dried at 55°C, ground through a Wiley mill (2-mm screen), and composited at the end of each collection period. Feed andorts were analyzed for DM and OM (AOAC, 1980). Nitrogen was measured using the Kjeldahl method (AOAC, 1980). Neutral detergent fiber (NDF) was measured using the procedure of Robertson and Van Soest (1977) as modified by Jeraci et al. (1988). Acid detergent fiber (ADF) and acid detergent lignin (ADL) were measured according to Goering and Van Soest (1970). Body weights were taken on d-1 and 15 of each period.

Data were analyzed by analysis of variance for a completely randomized design (CRD) according to the General Linear Models (GLM) procedure of SAS (1982). Model sums of squares for the CRD included animal, period, and diet effects. Sums of squares for diet effects were separated further into orthogonal contrasts.

Contrasts for the OH experiment were: diet 5 vs all other diets, diet 1 vs diet 5, diet 1 vs diets 2 and 3, diets 2 and 3 vs diet 4, and diet 3 vs diet 6. The contrast for the RS experiment was AHP-RS vs untreated RS. The following single observations were lost: commercially treated AHP-OH diet (period 1), AHP-treated RS diet (period 1), and untreated RS diet (period 2) for reasons unrelated to treatment.

RESULTS AND DISCUSSION

Chemical composition of feeds used in the digestibility experiments is presented in Table 2. Oat hulls were AHP treated using five different procedures. The first treatment consisted of AHP-OH at a low (17.9%) moisture level (diet 1). The second treatment was AHP-OH prepared at a lower (1%) hydrogen peroxide level than normal (2%); diet 2. The third treatment consisted of AHP-OH prepared at a high (36.0%) moisture level (diet 3). The fourth treatment consisted of pelleted AHP-OH at 14.7% moisture (diet 4). The control diet was untreated OH (diet 5). The treatment (sixth test diet) involved commercial preparation of AHP-OH (diet 6). This was done to determine if AHP treatment of OH would be equally efficacious using different treatment facilities. Two RS treatments were tested: AHP-RS at 35.7% moisture (diet 7) and untreated RS (diet 8). Treatment of OH and RS with AHP appeared to solubilize a portion of the structural carbohydrate fraction of the cell wall matrix when compared with untreated

residues. Alkaline hydrogen peroxide-treated OH averaged 12.9 percentage units less NDF when compared with untreated OH. Percentage ADF decreased slightly for the AHP-OH treatments compared to the untreated OH. Treatment 3 (high moisture) had a greater NDF loss in comparison to treatment 1 (low moisture). This may be attributed to the higher level of moisture during the treatment process, allowing for a more favorable treatment response. This suggests that increasing moisture content of the cell wall of the byproduct allows for a more thorough application of the chemicals, thus increasing the area that fiber-digesting microorganisms may attack. Treatment of RS with AHP decreased NDF content by 10.8 percentage units with little effect on ADF content. There was a slight decrease in ADL content in both AHP-OH and AHP-RS when compared to the untreated residues. Both AHP-OH and AHP-RS are higher in cell wall carbohydrates as compared to alfalfa hay.

The least square means for nutrient intakes, apparent nutrient digestibilities, and digestible nutrient intakes are presented in Tables 3 and 4. Dry matter intakes and digestible DM intakes were increased such that wethers fed the AHP-OH diets consumed, on average, 484 g/d and 458 g/d more DM and digestible DM, respectively, than wethers fed the untreated OH diet. There was no effect of pelleting (diet 4) on DM intake (in comparison to diets 2 and 3). However, apparent DM digestibility of diet 2 and 3 DM ($P < .01$) increased (68.1%) when compared to diet 4 (61.0%). In addition, wethers fed diets 2 and 3 had higher ($P < .05$) DM

digestibility (68.1%) compared to wethers fed diet 1 (63.5%). This suggests that moisture level is important in obtaining an optimal response with the AHP-treatment procedure and, in this study, the higher moisture level (diets 2 and 3) resulted in increased DM digestibility when compared to the low moisture treatment (diet 1). Intake, expressed as a percentage of body weight (BW), was increased ($P < .01$) to 4.4% for wethers fed the AHP-OH diets vs 3.1% for wethers fed the untreated OH diet (diet 5). There was also a difference ($P < .05$) in intake, expressed as a percentage of BW, between wethers fed diet 4 vs those fed diets 2 and 3. Generally, pelleting a low quality forage will increase DM intake when compared to feeding coarse-chopped or long-stem roughage diets.

Alkaline hydrogen peroxide treatment of RS increased ($P < .01$) DM digestibility (Table 4) to 67.7% compared with 55.6% for the untreated RS diet (diet 8). It was observed that during the adaptation phase of each period, wethers fed AHP-OH diets reached maximal intakes sooner in each period than did wethers fed the untreated OH or either of the RS diets, suggesting that diets containing the AHP-OH were more acceptable. It also was observed that wethers continually lost BW during each period when fed either of the RS-based diets resulting in an average loss of 7 kg per wether for the trial.

Organic matter (OM) intake and apparent OM digestibility followed similar trends to those of DM, with wethers fed the AHP-OH

diets consuming more (1283 g/d) than the wethers fed the untreated OH diet (890 g/d). Organic matter digestibility averaged 65.6% for AHP-OH diets compared to 51.9% for wethers fed the untreated OH diet, an increase of 13.7 percentage units. This resulted in 381 g/d more digestible OM intake by wethers fed the AHP-OH diets. Data indicated that OM digestibility was greater ($P < .05$) for diets 2 and 3 (average, 68.5%) when compared to diet 1 (63.5%). There was also a decrease ($P < .01$) in OM digestibility to 61.0% for wethers fed diet 4 from an average of 68.5% for wethers consuming diets 2 and 3. Organic matter digestibility (Table 4) by the wethers fed RS was increased ($P < .01$) from 58.2% for those fed the untreated RS diet to 70.7% for those fed the AHP-RS diet.

Crude protein digestibility by wethers was higher ($P < .01$) for the untreated OH diet in comparison to the AHP-OH diets, suggesting that the low CP intakes by wethers fed diet 5 resulted in a slower turnover rate which increased digestion of CP as time spent in the gastrointestinal tract probably was increased. However, digestible CP intakes by wethers fed AHP-OH diets were higher at 161 g/d compared to 125 g/d for the untreated OH diet. Crude protein digestibility was higher ($P < .05$) for treatment 1 (76.6%) when compared to treatments 2 and 3 (71.4%), resulting in an increased digestible CP intake of 16 g/d. Digestibility of CP also was higher ($P < .01$) for treatment 4 (79.0%) when compared to treatments 2 and 3 (71.4%), resulting in an increase in digestible CP intake of 28 g/d. Treatment of RS with AHP had no effect on CP intake, CP

digestibility, or digestible CP intake when compared to wethers fed the untreated RS diet (Table 4).

Wethers fed the AHP-OH diets consumed, on average, 427 g/d digestible NDF while wethers fed the untreated OH diet consumed 193 g/d digestible NDF. This is a 2.2-fold increase in digestible NDF intake. Wethers fed diets 2 and 3 consumed, on average, 112 g/d more digestible NDF than did those fed diet 4. In addition, there was an increase ($P<.01$) in NDF digestibility to 64.4% for wethers fed diets 2 and 3 vs 53.4% for wethers fed diet 1. It appears that higher moisture levels resulted in a more optimal treatment response which may increase susceptibility of plant structural carbohydrates to fiber-digesting microorganisms and allow for higher NDF digestibility. Furthermore, there were differences ($P<.05$) in NDF digestibility between diet 3 (66.0%) and diet 6 (59.6%), suggesting that the AHP treatment response for OH can be variable among treatment facilities. Alkaline hydrogen peroxide-treatment of RS increased ($P<.01$) apparent NDF digestibility (66.6%) when compared to the untreated RS control (45.5%), yet no differences in digestible NDF intake were noted (Table 4).

Acid detergent fiber intakes and digestibilities followed similar trends to those of NDF; however, there was less of an effect among the different treatment procedures. Alkaline hydrogen peroxide-treatment of OH increased ($P<.01$) digestible ADF intake by 151 g/d when compared to the untreated OH diet, a 2.8-fold

increase. Acid detergent fiber digestibility ($P<.1$) increased to 55.6% for diets 2 and 3 when compared to 40.7% for diet 4. Alkaline hydrogen peroxide-treatment of RS (Table 4) increased ($P<.01$) ADF digestibility from 36.5% for wethers fed the untreated RS to 55.5% for wethers fed the AHP-RS diets, but no effects on ADF intake or digestible ADF intake were noted.

In summary, the results with OH suggest that growing wethers fed diets containing AHP-OH had higher nutrient intakes and fiber digestibilities when compared to wethers fed the diet containing untreated OH. Alkaline hydrogen peroxide treatment of RS increased nutrient digestibilities, except for CP, when compared to untreated RS. Variations in treatment procedures affect nutrient digestibilities, while intakes and digestible nutrient intakes remain somewhat constant. The higher moisture level at the time of AHP treatment results in increased digestibilities of DM, OM, and NDF when compared to the low moisture AHP-treatment of OH. Pelleting of AHP-OH appeared to decrease digestibilities of DM, OM, NDF, and ADF when compared to unpelleted AHP-OH. The only significant difference between facilities (diet 3 vs diet 6) occurred in NDF digestibility. The AHP treatment of OH at the high moisture level resulted in increased nutrient digestibilities and subsequent increases in digestible nutrient intakes. Although AHP treatment of RS significantly increased nutrient digestibilities of DM, OM, NDF, and ADF, digestible nutrient intakes were not improved as a result of the low intakes.

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TABLE 1. Ingredient composition of diets.

Item	Diet ¹							
	1	2	3	4	5	6	7	8
	-----				%	-----		
AHP-OH	65	65	65	65		65		
AHP-RS							65	
Untreated OH					65			
Untreated RS								65
Alfalfa Hay	15	15	15	15	15	15	15	15
Concentrate ²	20	20	20	20	20	20	20	20

¹Diet 1 = low moisture (17.9%) AHP-OH; Diet 2 = low hydrogen peroxide (1%) AHP-OH; Diet 3 = high moisture (36.0%) AHP-OH; Diet 4 = pelleted AHP-OH (14.7% moisture); Diet 5 = untreated OH; Diet 6 = commercially processed AHP-OH; Diet 7 = AHP-treated RS; Diet 8 = untreated RS.

²Contained soybean meal (87.64%), ground shelled corn (4.90%), potassium chloride (2.28%), trace mineral salt (1.38%), vitamin premix (1.38%), dicalcium phosphate (.91%), calcium sulfate (.78%), and limestone (.73%). Trace mineral salt and vitamin premix contained a minimum percentage of the following minerals: iodine (.025), iron (2.0), zinc (3.0), manganese (3.0), magnesium (5.0), copper (.5), cobalt (.004), selenium (.015), sulfur (10.0), and potassium (7.5). Vitamin A (2,200,000), Vita-min D₃ (660,000), and Vitamin E (7,700) are expressed as IU/kg premix.

TABLE 2. Chemical composition of feeds used in growing wether diets.

Ingredient	Chemical component					
	DM ¹	OM	CP	NDF	ADF	ADL
	----- % DM -----					
AHP-OH ²						
Trt 1	82.1	88.5	4.4	70.3	39.8	6.7
Trt 2	65.5	89.9	4.6	68.6	38.8	6.3
Trt 3	64.0	88.5	4.3	63.2	38.9	6.5
Trt 4	85.3	90.0	4.5	66.5	37.5	6.4
Trt 6	81.4	88.5	4.4	65.3	38.0	7.2
Untreated OH	86.3	94.8	4.7	79.7	40.7	7.4
AHP-RS ²	64.3	75.9	8.3	63.1	48.4	6.7
Untreated RS	88.3	79.8	8.8	73.9	49.0	7.5
Alfalfa hay ³	89.6	89.8	18.0	49.0	35.9	8.6
Concentrate	90.0	86.0	45.2	10.6	6.1	.9

¹DM on an as-fed basis.²AHP-OH = alkaline hydrogen peroxide-treated oat hulls.

AHP-RS = alkaline hydrogen peroxide-treated rice straw.

³Chopped alfalfa hay.

TABLE 3. Least squares means for nutrient intake, apparent nutrient digestibility, and digestible nutrient intake of chemically treated or untreated oat hull-based diets fed to growing wethers.

	Diet ¹						Pooled SEM
ITEM	1	2	3	4	5	6	
Intake, g/d							
DM ^{a,b}	1490	1472	1345	1526	961	1392	63.0
OM ^{a,b}	1329	1311	1188	1360	890	1228	56.3
CP ^{a,b}	222	224	207	233	147	206	8.7
NDF ^{a,b,d}	828	780	665	788	593	713	35.3
ADF ^{a,b}	478	461	427	461	305	434	21.2
Apparent digestibility, %							
DM ^{a,b,d,e}	63.5	68.1	68.0	61.0	51.0	66.8	1.4
OM ^{a,b,d,e}	63.5	68.6	68.4	61.0	51.9	66.7	1.4
CP ^{a,b,d,e}	76.6	73.4	69.3	79.0	83.5	71.8	1.6
NDF ^{a,b,c,e,h}	53.4	62.9	66.0	46.9	33.7	59.6	2.1
ADF ^{a,b,g}	56.3	52.5	58.7	40.7	30.8	50.7	6.5
Digestible nutrient intake, g/d							
DM ^{a,b}	945	1002	904	931	479	922	41.5
OM ^{a,b}	844	899	803	812	453	812	37.7
CP ^{a,b,d,e}	170	164	143	182	125	148	4.4
NDF ^{a,b,e}	445	492	430	349	192	416	25.2
ADF ^{a,b}	285	248	243	176	84	221	36.2
Intake, % of BW ^{a,b,f}							
	4.4	4.5	4.1	4.7	3.1	4.2	.2

¹Diet 1 = low moisture (17.9%) AHP-OH; Diet 2 = low hydrogen peroxide (1%) AHP-OH; Diet 3 = high moisture (36.0%) AHP-OH; Diet 4 = pelleted AHP-OH (14.7% moisture); Diet 5 = untreated OH; Diet 6 = commercially processed AHP-OH.

Contrast: Diet 5 vs all other diets; ^aP<.01
Diet 1 vs Diet 5; ^bP<.01
Diet 1 vs Diets 2 and 3; ^cP<.01, ^dP<.05
Diets 2 and 3 vs Diet 4; ^eP<.01, ^fP<.05, ^gP<.1
Diet 3 vs Diet 6; ^hP<.05

TABLE 4. Least squares means for nutrient intake, apparent nutrient digestibility, and digestible nutrient intake of chemically treated or untreated rice straw-based diets fed to growing wethers.

Item	Diet ¹		Pooled SEM
	7	8	
Intake, g/d			
DM	699	730	134.1
OM	566	610	108.3
CP	127	123	27.3
NDF	366	422	71.5
ADF	270	277	52.2
Apparent digestibility, %			
DM ^a	67.7	55.6	1.3
OM ^a	70.7	58.2	1.5
CP	76.1	77.0	1.2
NDF ^a	66.6	45.1	2.2
ADF ^a	55.5	36.5	2.5
Digestible nutrient intake, g/d			
DM	468	415	96.3
OM	396	366	81.0
CP	96	96	22.3
NDF	237	205	50.3
ADF	148	110	31.6
Intake, % of BW	2.1	2.0	.4

¹Diet 7 = AHP-treated RS; Diet 8 = untreated RS.

^aP<.01.

THE EFFECT OF MELENGESTROL ACETATE ON THE FERTILITY OF BEEF HEIFERS

D. J. Kesler, L. L. Berger, D. B. Faulkner and R. J. Favero

SUMMARY

Beef heifers were fed a ration with (n=17) or without (n=16) melengestrol acetate (MGA) for 11 weeks. Five days after the last feeding all heifers were administered the Syncro-Mate B estrous synchronization procedure. Pregnancy rates to the timed artificial insemination were similar regardless of the addition of MGA to the feed. Therefore long term feeding of MGA alone is not detrimental to reproductive function.

INTRODUCTION

Estrous synchronization procedures have been developed which use melengestrol acetate (MGA) to suppress estrus in beef females. This type of a program is attractive to some producers because the compound can be fed and does not require the number of animal handlings or animal restraints that other estrous synchronization procedures require. Research has shown that reduced fertility is associated with the first estrus following a prolonged feeding (>12 days) of MGA. Consequently most procedures utilize a 12 to 14 day feeding of MGA which is followed by an injection of prostaglandin $F_{2\alpha}$ approximately 14 days after the last MGA feeding. Following the injection most females will display estrus, but the interval from injection to estrus is variable and will not allow a timed artificial insemination. It is the opinion of these authors that the stage of the estrous cycle at the initiation of an estrous synchronization procedure, and more importantly the interval between ovulations has an effect on the fertility at the synchronized estrus. The reduced fertility associated with prolonged feeding of MGA may be more a function of an increased interval between ovulations than carry-over effects of the progestin. The purpose of the study reported herein is to investigate if MGA feeding can be followed with a Syncro-Mate B estrous synchronization procedure which utilizes a timed artificial insemination.

PROCEDURE

Beef heifers (n=33) were randomly assigned to treated or control groups. Treated heifers received approximately .5 mg melengestrol acetate (MGA) daily, in a complete mixed ration. Control heifers received the same ration except that it did not include the MGA. The ration was fed continuously for approximately 11 weeks. Five days after the last feeding of MGA, all heifers were administered Syncro-Mate B (SMB). The SMB treatment consists of a 6.0 mg norgestomet ear implant which is subcutaneously inserted in the convex surface of the ear. At the time of implant insertion an intramuscular injection of 5.0 mg of norgestomet and 3.0 mg of

estradiol valerate was administered. The norgestomet implant was removed after 9 days. Approximately 47 hours after implant removal all heifers were artificially inseminated. Rectal palpation of the reproductive tract was conducted on day 63 after AI to determine pregnancy rate.

RESULTS

The results of this study are shown in Table 1. The long-term feeding of melengestrol acetate (MGA) had no adverse effects on the fertility on a synchronized estrus following MGA feeding. Numerically the pregnancy rate of the treated heifers was higher, but with the small numbers in the study the difference was non-significant.

CONCLUSIONS

Prolonged feeding of MGA had no adverse effects on fertility of SMB synchronized beef heifers. Prior feeding of MGA may have increased pregnancy rate by having treated heifers at an early stage of the estrous cycle at the initiation of the SMB synchronization procedure. This would insure that the females did not have an increased interval between ovulations, which may be detrimental to fertility.

TABLE 1. FERTILITY OF BEEF HEIFERS PREVIOUSLY EXPOSED TO PROLONGED FEEDING OF MGA PRIOR TO SMB ESTROUS SYNCHRONIZATION

Treatment Group ¹	n	Conception Rate (%)
Control	16	4/16(25)
Treated	17	8/17(47)

¹Treated heifers were fed .5 mg MGA daily for 11 weeks and SMB was administered 3 days after the last day of MGA feeding.

THE EFFECT OF REPETITIVE SYNCRO-MATE B TREATMENT ON FERTILITY OF BEEF HEIFERS

R. J. Favero, D. B. Faulkner, J. W. Castree and D. J. Kesler

SUMMARY

Utilizing the Syncro-Mate B (SMB) injection along with a norgestomet implant decreased ($P < .01$) the pregnancy rate of previously synchronized beef heifers to almost zero. The norgestomet implant alone has been demonstrated to enhance the previously synchronized pregnancy rate. Therefore, the SMB injection would appear to be luteolytic when administered on day 12 after conception.

INTRODUCTION

In previous reports we have demonstrated that norgestomet (N) implants administered on days 12 to 21 after a synchronized artificial insemination (AI) increased the conception rate to the initial AI. Norgestomet implants inhibited estrus and thus upon removal synchronized estrus in the non-pregnant females.

The purpose of the study reported herein is to investigate the effect of the administration of a complete Syncro-Mate B treatment (a 9 day N implant and an injection of 5.0 mg estradiol valerate and 3.0 mg N at implantation) administered on day 12 following a synchronized AI.

PROCEDURES

Estrus in 41 yearling beef heifers was synchronized using Syncro-Mate B (SMB). The SMB treatment involves a 6.0 mg norgestomet (N) implant that is subcutaneously inserted into the convex surface of the ear. At the time of implantation an injection of 5.0 mg of estradiol valerate (EV) and 3.0 mg N is administered. After 9 days the implant is removed and all heifers are artificially inseminated (AI) approximately 47 hours after implant removal. Twelve days after AI heifers were assigned to control or treated groups. All control and treated heifers received one N ear implant. Treated heifers also received an intramuscular injection that contained 5.0 mg EV and 3.0 mg N. Nine days after implant insertion (day 21 after AI) the N implants were removed. Pregnancy status was determined by rectal palpation of the reproductive tract on day 63 after AI.

RESULTS AND DISCUSSION

One of the treated heifers was eliminated from the study because the second norgestomet implant was lost. Results for the other 21 treated and 19 control heifers are summarized in Table 1.

CONCLUSIONS

We have previously demonstrated the efficacy of norgestomet implants 12 to 21 days post AI. This study would demonstrate the importance of observing our previous protocol. One cannot simply utilize the commercially available Syncro-Mate B (SMB) procedure. The results would suggest that the SMB injection (that contains both estradiol valerate and norgestomet) is luteolytic. This is in contrast to the reputed theory of SMB treatment to bovine females during mid to late luteal phase. These results would also suggest that SMB is an abortifacient. These results, however, are based on one limited stage of pregnancy (approximately day 12).

TABLE 1. PREGNANCY RATES OF HEIFERS ADMINISTERED NORGESTOMET IMPLANTS (CONTROL) OR SMB (TREATED) TWELVE DAYS AFTER AI

Treatment Group	Pregnancy Rates
Control (Norgestomet Implant)	10/19 (52.6%)
Treated (SMB)	1/21 (4.8%) ¹

¹Groups are significantly different ($P < .01$).

FERTILITY OF PRENATALLY ANDROGENIZED FEMALES

D. J. Kesler, L. L. Berger, D. B. Faulkner, K. C. DeHaan
and R. J. Favero

SUMMARY

Sixty-five untreated and 50 prenatally androgenized beef heifers at two locations were synchronized with Syncro-Mate B and artificially inseminated (AI) 47 hours after implant removal. All heifers that returned to estrus in the first 25 days of the breeding season were inseminated a second time. In Trial 1 natural service was used for the remainder of the 60 day breeding season, while AI was used as the method of rebreeding in a 70 day breeding season in Trial 2. Pregnancy rates (first service and end of the breeding season) were higher for prenatally androgenized heifers than for control heifers at both locations. Therefore, prenatal androgenization does not adversely affect fertility.

INTRODUCTION

It has been well documented that exposure of unborn female calves to testosterone propionate (prenatal androgenization) increases postnatal growth and performance. Past studies have been focused on the growth and carcass characteristics of the prenatally androgenized females. The purpose of this study was to investigate the effect of prenatal androgenization on the fertility of yearling beef females.

PROCEDURES

Crossbred beef females (n=235) were randomly assigned to treated or control groups 30 days after the end of a 60 day breeding season. Treated females were administered 4 testosterone propionate (TP) implants each. The implants were made of a medical grade silicone tubing with an internal diameter of .635 cm and an external diameter of .953 cm. Implants were 15 cm in length and contained approximately 2.25 g of TP. Implants were subcutaneously inserted behind the shoulder and over the dorsal aspect of the rib cage. Implants were removed approximately 3 weeks prior to the onset of the calving season.

The resulting prenatally androgenized (offspring of TP treated cows; n=50) and control heifers (n=66) were weaned from their dams at approximately 7 months of age and were retained as replacement heifers for the beef herd. This study was conducted in two trials, Trial 1 was conducted at the beef unit at the Dixon Springs Agricultural Center at Simpson, Il. and Trial 2 was conducted at the Orr Beef Research Center at Perry, Il. Prior to and during the breeding season, control and treated heifers were maintained together. In both trials, estrus was synchronized with Syncro-Mate B (SMB). The SMB procedure consists of a norgestomet (N) implant which is subcutaneously inserted into the convex surface of the

ear. At the time of implant insertion an intramuscular injection of 5.0 mg of estradiol valerate and 3.0 mg of N was administered. The N implant was removed at the end of 9 days. Approximately 47 hours after implant removal all heifers were artificially inseminated (AI). In trial 1, heifers that returned to estrus in the first 25 days of the breeding season were artificially inseminated a second time. Natural service was used on days 25-60 of the breeding season. In trial 2, estrus detection and AI were used throughout a 70 day breeding season. Rectal palpation of the reproductive tract was conducted on days 63 and 153 after the initial AI to determine pregnancy rate to the synchronized AI and overall pregnancy rate.

RESULTS

Results (summarized in Table 1) were similar between both locations. Prenatal androgenization clearly had no adverse effects on reproductive function. In fact one could speculate that fertility was enhanced by prenatal androgenization.

CONCLUSION

Prenatal androgenization does not adversely affect reproductive function.

TABLE 1. EFFECT OF PRENATAL ANDROGENIZATION ON REPRODUCTIVE PERFORMANCE OF BEEF HEIFERS

<u>Trial</u>	<u>Control</u>	<u>Treated¹</u>
	<u>First Service Pregnancy Rate (%)²</u>	
1	17/49(35) ³	15/33(45)
2	4/16(25)	8/17(47)
Combined	21/65(32)	23/50(46)
	<u>Pregnancy Rate - End of Breeding Season (%)</u>	
1	37/50(74)	27/33(82)
2	10/16(63)	13/17(76)
Combined	47/66(71)	40/50(80)

¹Treated heifers were prenatally androgenized.

²Conception rate to the initial SMB timed AI.

³One control heifer lost the SMB implant and was not included in the first service conception rate.

THE EFFECT OF TESTOSTERONE TREATED GOMER COWS ON POSTPARTUM REPRODUCTION

D. J. Kesler, D. B. Faulkner, G. F. Cmarik, and R. J. Favero

SUMMARY

One hundred and seventy suckled beef cows were randomly assigned to one of two groups at parturition. Treated cows were exposed to testosterone-treated gomer cows. Ovarian cyclicity was determined just prior to the breeding season. A higher percentage of the cows exposed to the testosterone-treated gomer cows were cyclic at the beginning of the breeding season. This was particularly apparent for cows that were at an earlier postpartum stage.

INTRODUCTION

The length of the anestrus period after parturition is one of the main factors limiting beef cattle productivity. In order for a beef cow to maintain a one year interval between calves she must be pregnant within 80 to 90 days after calving. If females are young, have a long gestation, are heavily lactating and/or nutritionally deficient, then this may be a difficult goal.

Previous studies have found that exposure of postpartum cows to bulls will stimulate estrous cyclicity at an earlier stage postpartum. Intact, vasectomized or surgically altered bulls will reduce the interval from calving to first postpartum estrus by 15 to 20 days. In previous studies we have demonstrated that beef females treated with testosterone develop male sexual behavior patterns and can be used as gomer animals for estrous detection. The study reported herein investigates the effect of testosterone treated cull cows on the anestrus period of suckled postpartum beef females.

PROCEDURE

Approximately 170 spring calving beef cows and first calf heifers were maintained at the University of Illinois Beef Cattle Research Unit at the Dixon Springs Agricultural Center near Simpson, Illinois. All cows were fed 10 pounds of corn silage and 1 pound of a 40% crude protein corn:urea mix daily. Cows had access to fescue hay and fescue pasture before and after calving.

Approximately 1 week prior to the initiation of the calving season 6 non-pregnant beef females were treated with 4 testosterone propionate implants each (gomer cows). The implants were made of a medical grade silicone tubing with an internal diameter of .635 cm and an external diameter of .953 cm. Implants were 15 cm in length and contained approximately 2.25 g of testosterone propionate. Implants were subcutaneously inserted behind the shoulder and over the dorsal aspect of the rib cage. Additionally

the 6 testosterone treated gomer cows received a subcutaneous injection of 1.0 g testosterone enanthate dissolved in 10 ml of absolute ethanol each. Past studies have demonstrated that the above testosterone-treatment is able to induce and maintain male behavior patterns in beef females.

Shortly after calving, females were randomly assigned to similar pastures that contained 2 testosterone-treated cows (gomer cows) or pastures that contained no gomer cows. As the pastures became fully stocked, additional pastures were used. A total of 3 pastures with gomer cows and 3 control pastures were used. In late march serum samples were collected from all cows. A second serum sample was collected eleven days after the first. At the time of the second blood sample, an estrous synchronization program using Syncro-Mate B was initiated.

A validated enzyme immunoassay was used to determine progesterone concentrations of all serum samples. Progesterone concentrations greater than 1.5 ng/ml in one or both of the serum samples indicates that the female is exhibiting estrous cycles. If both of the serum samples had progesterone levels less than 1.5 ng/ml then the female is anestrous and has not initiated estrous cycles after calving.

RESULTS

The females that were treated with testosterone (gomer cows) did exhibit male sexual behavior patterns. Gomer cows moved through the herd attempting to locate females that were in estrus. The gomer cows displayed an intense interest in females that were in estrus and frequently mounted estrous females.

A total of 6 pastures were used for this experiment, 3 of the pastures housed control cows and 3 pastures contained gomer cows. A high proportion of the cows calved early in the calving season. Therefore data were combined for the first 2 pastures of control and gomer exposed cows. The number of cows, stage postpartum and average days postpartum is shown in Table 1. It can also be seen that cows that are at an early postpartum stage (late calvers) may benefit the most from gomer cow exposure. Overall gomer cows appear to induce estrous cycles at an earlier postpartum stage in suckled beef cows.

CONCLUSIONS

Gomer cows increased the proportion of suckled beef cows that were exhibiting estrous cycles prior to the initiation of the breeding season. In breeding programs utilizing artificial insemination, gomer cows may be beneficial by aiding in estrous detection and by helping to reduce the interval to estrus following calving.

TABLE 1. EFFECT OF GOMER COWS ON ESTROUS STATUS OF POSTPARTUM BEEF COWS.

Treatment Group	n	Stage Postpartum	Average Days Postpartum	Percent Cyclic ¹
Control	34	Early	56.5	41.2
Gomer exposed	33	Early	57.4	63.6
Control	54	Late	81.5	79.6
Gomer exposed	50	Late	81.5	84.0
Overall				
Control	88	All	71.8	64.8
Gomer exposed	83	All	71.9	75.9

¹Percent of females that had initiated estrous cycles prior to the breeding season, based on elevated progesterone concentrations.

THE EFFECT OF RESYNCHRONIZATION OF BEEF FEMALES BRED BY VARIOUS METHODS

R. J. Favero, D. B. Faulkner, G. F. Cmarik, and D. J. Kesler

SUMMARY

In 4 trials beef females (n=309) were initially synchronized with Syncro-Mate B (SMB). Twelve days after the SMB timed artificial insemination (AI), all females received a norgestomet ear implant for 9 days. At the time of norgestomet implant removal (day 21 post SMB timed AI) females were assigned to control and treated groups. Estrus in control females was visually detected and AI was performed approximately 12 hours following detection of estrus (Trials 1, 2 and 3). Treated females in Trial 1 were visually detected for estrus, but all AI were conducted at 47 hours after implant removal. In Trials 2 and 3, treated females that had low serum progesterone concentrations at implant removal were AI at 47 hours after implant removal. In Trial 4, control females were treated the same as treated females in Trials 2 and 3 whereas treated females were all AI irregardless of corpus luteum status. In all Trials 1, 2, 3 and control females in Trial 4, the results indicate that timed AI was as good, if not superior to, breeding based on detected estrus and the AM/PM rule. Breeding however, should not be conducted without some regard to corpus luteum status.

INTRODUCTION

Several methods have been developed to effectively synchronize estrus in beef females. Some of these methods of estrous synchronization achieve the precision required for a single timed artificial insemination (AI). Females that do not conceive to the timed AI return to estrus approximately 17 to 23 days later, and estrous detection is required if the females are going to be bred by AI.

In previous reports we have demonstrated that norgestomet implants administered on days 12 to 21 after a synchronized AI 1) increased the conception rate to the previous AI and 2) synchronized estrus in the non-pregnant females. In this study we investigated the use of timed methods of rebreeding at the return estrus, thus allowing for two synchronized timed AI.

PROCEDURES

Beef females were initially synchronized using Syncro-Mate B. The Syncro-Mate B treatment consists of administration of a 6.0 mg norgestomet ear implant and an injection of 5.0 mg of estradiol valerate and 3.0 mg of norgestomet. The implant was inserted subcutaneously into the convex surface of the ear. After 9 days the implant was removed and all females were artificially inseminated (AI) approximately 47 hours after implant removal.

Females that exhibited estrus in the first 12 days after AI were removed from the study. On day 12 after AI females were administered a silicone ear implant that contained approximately 3.6 mg of norgestomet. The implant was removed 9 days after insertion (day 21 post AI).

This study involved 4 trials, in Trial 1, 90 heifers were used. Trial 2 utilized 90 heifers, Trial 3 included 90 postpartum suckled cows and Trial 4 utilized 39 heifers. At the time of implant removal the females were randomly assigned to treated or control groups. Additionally at the time of implant removal serum samples were collected from all females. Serum progesterone concentrations were determined by validated enzyme immunoassay. In Trials 1, 2 and 3 the females in the control groups were artificially inseminated approximately 12 hours after being detected in estrus (Table 1). Estrus detection was conducted on the treated females in Trial 1, but all artificial inseminations were preformed at approximately 47 hours after implant removal regardless of when estrus was detected. If the treated females in Trials 2 and 3 or the control heifers in Trial 4 had progesterone concentrations less than 1.5 ng/ml at the time of norgestomet implant removal, then the female was AI 47 hours after implant removal. In Trial 4 all treated females were AI 47 hours after implant removal regardless of corpus luteum status. Pregnancy rates were determined by calving dates for Trial 1 and by rectal palpation of the reproductive tract in Trials 2, 3 and 4.

RESULTS

Females were randomly assigned to control and treated groups. Based on randomization the first service conception rate should have been equal for both control and treated groups. Overall this is true, however, there were obvious differences among trials. Overall, the first service conception rate is low (39%, Trials 1, 2 and 3, Table 2) however it should be noted that all animals were inseminated regardless of efficacy of the SMB treatment and regardless whether females displayed estrus or not.

This experiment was designed to analyze the effect of method of breeding at the second synchronization. Results (summarized in Table 2) demonstrate that timed AI was at least equal to, if not better, than breeding based on estrus and the AM/PM rule. Overall, 39% more females conceived if they were inseminated at a predetermined time than if they were bred by detected estrus (Trials 1, 2 and 3). Furthermore, 13% more females were inseminated if timed breeding was performed than if females were bred by estrus (Trials 1, 2 and 3). This resulted in an increase in the cumulative 2 time AI program (see Trials 1, 2 and 3, Table 2). In Trial 4 the mass breeding of the females appeared to decrease fertility. The control group in Trial 4 (see Table 2) was treated identical to the treated females in Trials 1, 2 and 3 and conception rates were similar (58% vs 60%). The heifers in Trial 4 that were mass inseminated had a cumulative conception rate of 40% or a 31% decrease.

CONCLUSIONS

The results of this study indicate that the breeding at the second AI at a predetermined time was not only equal to breeding by estrus but in fact resulted in more pregnancies over 2 AI's for 3 out of 3 years. Breeding, however, should not be done without regard to corpus luteum status.

TABLE 1. TREATMENT PROTOCOL FOR REBREEDING OF BEEF FEMALES FOLLOWING NORGESTOMET IMPLANT REMOVAL ON DAY 21 AFTER A SMB TIMED AI

Trial	Treatment Group	n	Estrous Detection Y or N	Method of Rebreeding
1	Control	52	Y	AI by AM/PM rule ¹
	Treated	52	Y	AI at 47 hours after IR ²
2	Control	41	Y	AI by AM/PM rule ¹
	Treated	41	N	AI at 47 hours if low P ₄ ³
3	Control	42	Y	AI by AM/PM rule ¹
	Treated	42	N	AI at 47 hours if low P ₄ ³
4	Control	19	N	AI at 47 hours if low P ₄ ³
	Treated	20	N	All females AI at 47 hours

¹AI approximately 12 hours after being visually detected in estrus.

²AI approximately 47 hours after implant removal if detected in estrus.

³AI approximately 47 hours after implant removal if day 21 serum progesterone concentrations were less than 1.5 ng/ml.

TABLE 2. EFFECT OF METHOD OF REBREEDING ON FERTILITY OF BEEF FEMALES

Trial	Treatment Group	First Service CR (%) ¹	Second Service CR (%) ²	Cumulative CR (%) ³
1	Control	22/52(42)	7/21(33)	29/52(56)
	Treated	16/52(31)	14/26(54)	30/52(58)
2	Control	13/41(32)	5/18(28)	18/41(44)
	Treated	21/41(51)	7/17(41)	28/41(68)
3	Control	18/42(43)	3/7(43)	21/42(50)
	Treated	18/42(43)	4/11(36)	22/42(52)
Overall	Control	53/135(39)	15/46(33)	68/135(50)
	Treated	53/135(39)	25/54(46)	80/135(59)
4	Control	9/19(47)	2/5(40)	11/19(58)
	Treated	6/20(30)	2/8(25) ⁴	8/20(40)

¹Conception rate to the initial SMB timed AI.

²Conception rate to the AI following Implant removal on day 21 after the initial SMB timed AI.

³Cumulative conception rate to the first and second AI.

⁴Based only on the females with low P₄. None of the females with high P₄ conceived to the second AI.

REDUCING ENERGY CONSUMPTION AND IMPROVING WATER QUALITY WITH BEEF CATTLE

Dan B. Faulkner

Appropriate utilization of forages and manure can reduce input costs and soil erosion on many farms. Beef cattle fit into such a farming system because of their unique ability to utilize forages and prosper with minimal management inputs. Other ruminant animals may utilize forage but they require more management. Profitable beef producers have year-round systems of beef production that maximize forage use by the grazing animal, minimize fertilization, minimize grain feeding and minimize the use of purchased supplemental feeds. This reduces farm expenses and limits the use of hydrocarbon based fuels for nitrogen fertilization and harvesting. This can result in economically profitable, environmentally sound, and biologically efficient alternatives for farm enterprises.

The integration of ruminants onto Midwest farms may improve productivity and profitability. The production of animal products is an excellent example of a value added enterprise, because livestock and crop production can be mutually supportive. The ruminants can graze forages and recycle nutrients through the decomposition of manure. Rotational grazing of grass/legume pastures, sequential grazing of cool and warm season grasses, and supplemental feeding of ruminants grazing crop residues can be used to control animal movement to further enhance the fertility contribution of manure. The challenge is to integrate economical production systems with available forage resources.

These systems should also have a positive impact on soil productivity and water quality. As concern about the environment increases, there is more interest in potential sources of surface and ground water contamination from agriculture. Cultivated rowcrop land and pasture are potential sources of concern. Pasture management practices have become increasingly dependent on the use of agricultural chemicals, specifically nitrogen fertilizer. The evaluation of sustainable management programs, that minimize surface water and ground-water contamination, becomes more critical if agricultural production and water quality are to coexist.

Hay and pasture land has a lower potential for contamination of surface and ground water than for crops. There is less water runoff from hay and pastures than from row crops. Water runoff from hay and pasture is cleaner than runoff from row crop land, has less soil sediment, has less fertilizer nutrients and has less pesticides. Pastures filter the runoff water, keeping a greater percentage of the water contaminants in the hay and pasture field than do row crops.

Hay and pasture use less pesticides than row crops. Herbicides may be used to establish perennial hay and pasture fields, but this occurs only once every 4 or more years. Herbicides may be used for maintenance of hay and pasture, but only if weed populations begin to depress production or present a health hazard to livestock. These applications are rarely over the entire acreage, thus the total amount of herbicide used is normally small. Insecticides are used for hay production and for some of the most productive pastures. The total insecticide application per acre to pasture is less than for hay, and both are less than for corn.

Much of the land in the midwest is subject to erosion. Erosion can be reduced if appropriate rotation, tillage and management practices are utilized. The crop residues can be an economical feed resource, particularly if they are strip grazed and if some residue is left in the field to control soil erosion. Many farms have some land that is not suitable for row crop production. Erosion can be controlled on this land with sod-forming grasses and legumes.

Cool-season grasses (e.g., tall fescue, orchardgrass, Kentucky bluegrass) make the majority of their growth in the spring and autumn. This growth pattern often leads to a deficiency of summer pasture for ruminants. When forage is a limiting factor, weight gains will be reduced unless harvested or purchased feeds are fed. Split applications of nitrogen fertilizer can improve the yield distribution of cool season grasses to a limited degree, but labor costs and the threat of water contamination may increase.

Generally, hay and pasture are fertilized at lower levels than row crops. Nitrogen is used on the more productive grass pastures, but rarely more than 150 pounds per acre. Although water runoff from hay fields and pastures can carry nitrogen, there is less nitrogen lost from hay fields and pastures than row crops because of the "filtering" action of hay and pasture plants and the lower net amount of nitrogen available for loss.

This midsummer problem is intensified because fescue is the predominant cool season grass in southern Illinois. Much of this fescue is infected with an endophytic fungus (Acremonium coenophialum) which reduces animal performance, particularly during the hot midsummer period. The endophytic fungus has been shown to reduce stocker cattle gains about 50 g/day for each 10 percentage unit increase in infection. Conception rate is also reduced when cows graze heavily infected tall fescue pasture. We have demonstrated that changing management practices (like calving season) can alleviate much of this problem. Legumes are particularly effective in reducing the toxic effects of the tall fescue endophyte when seeded in infected tall fescue pastures.

Legumes are also important in forage systems as a source of nitrogen for cool season grasses, improved forage yield during midsummer and high quality nutrients for the animal. Legumes grown in association with cool season grasses can improve the summer productivity of the pasture as well as eliminate the need for nitrogen (N) fertilizer. Legumes can be added to grass pastures with no-till seeding systems. Legumes provide the nitrogen needs of the associated grass and improve the feed nutrient value of the pasture for the grazing animal. Legumes produce nitrogen symbiotically with the proper Rhizobium bacteria. Symbiotically produced nitrogen has little risk of contaminating surface or ground water. The nitrogen is produced, stored and released from nodules on the legume root. The release rate is relatively slow so associated grasses or the legume plants themselves utilize the released nitrogen to make plants grow. Legumes reduce the dependency on petroleum derived nitrogen, but may require additional lime, phosphate, potash and other minerals, and pesticides to maintain high productivity. This could result in substantial energy savings since about 33% of the energy used in U.S. agriculture is used to produce N fertilizer.

Legumes have higher concentrations of crude protein, total nonstructural carbohydrates and digestible dry matter with lower concentrations of cell wall constituents (fiber) compared to grasses. Therefore, legumes can be effective in supplementing lower quality forages when added to the diet at the rate of 15-

30%. Illinois research has shown that the addition of alfalfa may increase rate, extent, and overall digestibility of the diet. Legumes used in a crop rotation as a source of nitrogen would be available for this type of supplemental cattle feeding.

Legumes are effective in improving animal performance when grazed and persist well when used in rotational grazing system. Sequential grazing demonstrations on farms in southern Illinois have shown animal gain per acre that would give similar returns to row crops based on commercial grazing costs.

Warm season grasses [e.g., big bluestem (Andropogon gerardii Vitman), switchgrass (Panicum virgatum L.)], as the name implies, produce most of their growth in the summer and provide another alternative forage system for midsummer. The different patterns of growth of cool season and warm season grasses permit a complementary pasture system to be developed. Furthermore, warm season perennial grasses require little nitrogen for high yields. We have evaluated warm season grazing systems for the past 4 years and found that more cattle can be grazed than on cool season grasses alone, but there also is a small decrease in animal performance.

It is important that the use of harvested forages in beef systems be minimized. Forage harvesting methods are energy intensive and utilization of stored forages may result in waste of up to 40% during harvest, storage and feeding. Reductions in the amount of harvested forage fed to beef cattle may be possible if the forage is accumulated, winter cover crops are grown, or if crop residues are utilized for late fall or winter grazing. It would be most efficient to utilize harvested forages only when necessary due to lack of pasture or snow cover.

Although grazing is the most economical part of the beef system, it cannot be utilized without an economical way of wintering ruminants. The total system must be considered as one begins to apply available technology to produce livestock economically. Producers need economical forage based systems to improve productivity and water quality.

During the past decade, studies world-wide have clearly shown that nitrates and some pesticides are being delivered to groundwater from routine agricultural practices. Regionally, in response to hydrologic settings, nitrates in groundwater has increased in a direct, linear fashion, paralleling the increased use of nitrogen fertilizers. Numerous studies show a direct relationship between the nitrate concentration in groundwater and nitrogen fertilizer rates. Surface water quality deterioration has also been linked to the application of nitrogen fertilizer to pasture land.

Our goal is to combine crop residues, winter cover crops, and forage resources into economical, environmentally sound production systems. Work in this area will continue at Dixon Springs Agricultural Center and at the Orr Center.

CROSSBREEDING PROGRAMS - PRACTICAL CONSIDERATIONS

D. F. Parrett

INTRODUCTION

Crossbreeding is a management tool that can increase net productivity by 20 percent or more over straightbreeding. Crossbreeding offers two major production advantages:

1. The desirable characteristics of two or more breeds can be combined together to achieve a better combination of traits than found in a single bred.
2. Crossbreeding allows the producer to benefit of heterosis (hybrid vigor), which allows the crossbred animal to perform better than average of the straightbred parent animals. Lowly heritable traits like fertility, calf survival and vigor respond well to crossbreeding.

In general, crossbred females are more fertile and heavier milking than straightbreds. The crossbred calves generally grow faster and have higher calf survival rates. Thus with improvements in fertility and growth rate, profit potential for a beef herd is generally increased.

Crossbreeding has many advantages and few disadvantages in general if the crossbreeding system and choice of breeds are based on sound information and if the crossbreeding system is practical. A practical system is one that matches well the management and resources of the operation.

High levels of heterosis increase efficiency and reduce the cost of producing beef. The level of heterosis in rotational crossbreeding systems increases as the number of breeds used in the rotation increases. All breeds of cattle would be used if level of heterosis were the only factor considered in beef production. However all breeds are not equally efficient for given production environments with varying feed and management resources.

Seldom can a cattleman let the demands of his cattle production system pull him too far away from his economically available forage resource without incurring substantial economic risk. This line of thinking does not rule out the judicious use of pasture improvement techniques, strategic supplemental feeding and other cost effective technology to enhance the productivity of the forage system. There is, however, a big difference between using cattle to package the forage that your land resource can economically produce as opposed to manufacturing feed to support the needs of a type of cattle you may happen to like. In other words, the feed resources should play a major role in dictating the production levels for various traits and the kinds of cattle that can profitably be produced.

DEVELOPING A CROSSBREEDING SYSTEM

In a stepwise fashion a producer should consider the following production guidelines:

- 1) Evaluate the production environment and the resources available. This includes the amount and quality of feed available, the length of the growing season and the flexibility of the forage system to adapt to extremes in weather changes.
- 2) Match the level of management to the environment. This includes the number of pastures available, whether or not AI will be utilized, time available for the producer to spend with the cattle and the ability of the producer to modify the environment without affecting cattle producing abilities.
- 3) Match the crossbreeding system to the environment. This primarily refers to the number of breeding pastures available and forage available for the cattle.
- 4) Match the type of crossbred cow to the environment. "Type" of cow considers cow size and milk production which will dictate feed requirements per cow.
- 5) Match the sire genotype to the dam type in accordance to crossbreeding system, management, and market. The sire genotype may already be determined by the crossbreeding system and type of cow. Rotational systems utilize different sire genotypes than a terminal sire system.

TYPES OF CROSSBREEDING SYSTEMS

Table one demonstrates the types of crossbreeding systems that can be adapted to most beef farms. A large majority of farms will be utilizing the one breeding pasture system.

TABLE 1. CROSSBREEDING SYSTEMS FOR ONE OR TWO BREEDING PASTURE OPERATIONS¹

Type of Crossbreeding System	Advantage (%) ²
<u>One Breeding Pasture</u>	
1. Buy F ₁ females, terminal sire	28%
2. Rotate sire breeds (3 breeds)	16%
3. Composite (3 or 4 breeds)	15%
4. Multiple sire breeds (3), X-bred female	15%
5. Multiple sire breeds (2), straight-bred female	7%
<u>Two Breeding Pastures</u>	
1. Rotate sire breeds (3) - terminal sire	25%
2. 2-breed rotation ¹ rotation sire breed	19%
3. 2-breed rotation	16%

¹Kress and Nelson (1988)

²Advantage in amount of calf weaned per cow exposed when compared to average of breeds involved in crossbreeding system. Also assumes cow breed type has been adequately matched to environment.

Of course an effective AI program allows a producer to utilize different sires even with only one breeding pasture. Heifers can be bred AI to calving ease bulls and mature cows to terminal sires. Cows can be bred AI once for replacement heifer production, then a terminal sire breed be used for natural service.

Rotational crossbreeding systems use some breeds proportionately more than others. A problem with rotational systems is that bulls of all breeds need to be available each year. Also cows need to be identified and sorted so that the next breed they are bred to is known. In extensive management systems this may be difficult.

BREED SELECTION

In general, breeds perform to definable performance levels. A good classification of breeds is shown in Table 2. This data was developed from research at the USDA Meat Animal Research Center in Clay Center, Nebraska. This center represents the most extensive research of beef breeds available. Of course we know that there is a great deal of variation within each breed and producers can choose animals within breeds to specific match their production goals.

TABLE 2. SELECTED BEEF BREED CLASSIFICATION BY BIOLOGICAL TYPES^A

Breed	Lean	Marbling	Milk	Puberty	Growth
Charolais	very high	low	low	late	very high
Chianina	very high	low	low	late	very high
Limousin	very high	low	low	late	moderate
Simmental	high	moderate	high	moderate	very high
Maine Anjou	high	moderate	high	moderate	very high
Gelbvieh	high	moderate	high	moderate	very high
South Devon	moderate	moderate	high	early	moderate
Tarentaise	moderate	moderate	high	early	moderate
Salers	moderate	moderate	high	early	moderate
Angus	low	high	moderate	moderate	moderate
Hereford	low	high	moderate	moderate	moderate
Shorthorn	low	high	moderate	moderate	moderate
Longhorn	low	high	moderate	moderate	low

^aBased on MARC data (Cundiff, et al., 1988.)

BREEDING PROBLEMS TO RESOLVE

We have already identified some practical limitations to developing a crossbreeding system (primarily number of pastures). Many specific questions have to be asked when choosing animal types. Some animal type questions to consider include:

- 1) Whether you can or will purchase replacement females. This decision is a primary one before finalizing a crossbreeding system.
- 2) Cow size must be matched to the available feed resources. Larger or smaller body size may have important biological advantages for adaptation to climate, feed resources, and marketing specifications. Large body size may have advantages in tolerance of cold stress and in efficient use of abundant feed supplies, whereas smaller size may be an advantage in hotter, drier climates with sparse seasonal grazing.
- 3) Antagonisms exist between growth and calving ease, between fleshing ability or marbling and carcass leanness, and between high productivity and maintenance requirements.
- 4) High levels of milk production result in more feed and higher quality feed for cows to stay productive. There are optimum levels of milk production which is not equal to maximum levels of milk production. If a producer retains ownership of his cattle to the yearling stage then increases in milk are not very important.
- 5) Optimum performance is not a single trait phenomenon; it is a multiple trait phenomenon. It is not sensible to apply selection on a single trait to the ultimate selection limit, there are too many trade-offs involved. The realistic approach would seem to be selection for optimum performance levels in traits important to economic efficiency.

BEEF PERFORMANCE RECORDS - FITTING EPD'S TO YOUR PRODUCTION OBJECTIVES

D. F. Parrett

INTRODUCTION

A beef cattle program is a long range program. The bulls selected to be used on commercial cows are the primary source of genetic improvement or change that occurs in that herd. The bulls supply half of genetics for each calf and when replacement heifers are retained, the bulls impact is magnified to up to 87% of the influence on the genetic make-up of future calf crops. It is critical for each producer to utilize all available information in order to buy bulls that will have a positive impact on a breeding program.

Genetic evaluation programs designed by a majority of the purebred breed associations have resulted in Expected Progeny Differences (EPD) as a powerful tool to use to make changes in a cattleman's breeding program.

An EPD is a prediction of how future progeny of a sire are expected to perform for a particular trait as compared to a fixed breed average. Difference is the key to understanding EPD. If bull A has a weaning weight EPD of +30 pounds and bull B has a weaning weight EPD of +5 pounds, and each is bred to a representative sample of your cowherd, you would expect the progeny of bull A to average 25 pounds $[+30-(+5)]$ more than bull B's offspring at weaning under the same management system.

There is no such thing as a "good" or "bad" EPD. What is "good" for one program or environment may be less than ideal for another. The EPD are not a contest or a race. Single trait selection has been proven to lead to negative changes in genetically correlated traits of economic importance. EPD should guide selection decision and aid producers in genetically describing the cattle they will utilize in their breeding programs. A simplified table of definitions for EPD is listed at the end of this paper.

DEFINING PRODUCTION GOALS

Before you begin to establish a bull's value, a producer must define his production goals and determine what traits need improvement. Some questions to consider:

- 1) What is the purpose of the bull? (e.g., calving ease, growth rate, sire replacement females, etc.)
- 2) In my production environment what are EPD optimums, or trait priorities? (e.g., feed and labor availability, sell calves at weaning, current herd milk levels, etc.)
- 3) Based on where I sell my cattle, what traits are most important?
- 4) What are the trade-offs for selecting for extremes in traits? (e.g., growth vs calving difficulty, milk production vs reproduction, etc.)

Utilizing EPD a producer can target his production objectives and breed to sire that will specifically change the important traits in his breeding program.

EXAMPLES TO FOLLOW

For example purposes , use the following list of bulls is being considered by producers to satisfy their breeding objectives.

EPD VALUES, 1b.

Bull	Birth	Weaning	Milk	Yearling
1	+5.2	+38.6	-3.2	+34.4
2	+1.2	+28.2	+7.3	+43.6
3	+2.5	+33.3	+13.6	+51.3
4	+0.3	+20.3	+11.4	+34.4

Given the following producer objectives then, select the best bull to fit the defined objectives.

<u>Producer</u>	<u>Selection Objectives</u>
A	Minimize calving difficulty in first calf heifers while maintaining good growth to weaning
B	Increase milking ability in a replacement females and post weaning gain in all calves
C	Use as a terminal sire to produce fast growing feedlot cattle, keeping back no replacement females

From the bulls given, producer A would select either bull 2 or 4. Bull 4 should sire the lightest calves. Unless the producer's heifers are small, bull 2 may sire acceptably light calves with more growth.

For producer B bulls 3 and 4 should sire daughters with improved milking ability, but bull 3 has a big advantage in post-weaning gain with a higher yearling EPD.

For producer C, bull 1 offers the most growth for cattle and his negative milk EPD is of no importance since no replacement females are to be retained. Bull 1 does have a higher birth weight EPD which could be a problem if a producer uses bull 1 on small cows or first calf heifers.

BALANCE TRAIT SIRES

Many producers with small herds use only one bull to breed to both heifers and mature cows. If this is the case, then birth weight EPD (i.e., calving ease) is a major priority in bull selection. Unfortunately it is hard to find bulls that are low birth weight and high growth. From our example data, bull 3 exhibits a good balance of all traits, if he is acceptable for birth weight.

Milk EPD are an indicator of how a bull's daughters milk production will influence weaning weight. Producers should remember that extremely high milk production levels demand increased feed for cows to stay fertile. Milk EPD need to be matched to feed resources available for a producer to optimize production. Growth traits generally should be maximized only after the birth weight and milk EPD optimums are established.

SELECTING BULLS FROM DIFFERENT BREEDS

An individual bull's EPD are generated within his breed and a producer should compare actual EPD values of animals only within the same breed. This allows a producer to identify sires or dams with advantages for selected traits. A purebred breeder should also look at an animal's EPD as compared to the breed average. This enables the producer to establish where the selected animal ranks for a trait within the breed population. Purebred breeders should utilize sires that rank in the top of their breed if they want to successfully change their breeding program. Each breed's EPD averages are developed from analyzing totally different data which has evolved over a varying number of years.

Breed average or the percentile ranking of a bull within his breed (top 10%, top 40%, bottom 30%, etc.) does offer a means for a producer to compare the relative value of bulls of different breeds. For example, an Angus bull with a +20 lb. weaning weight EPD will only be average (50%) for the Angus population. A Simmental bull with a +20 lb. weaning weight EPD will rank in the top 5% of the Simmental population for weaning weight. A producer looking to buy bulls of different breeds should be familiar with the relative ranking of EPD values in a specific breed population. A word of caution! Different breeds perform differently for selected traits. In general, some breeds are heavier milking, some grow faster, and some marble at earlier ages. However, EPD are still the best predictors available for determining genetic value. By establishing where a bull ranks within his breed population, a producer can begin to determine relative dollar values to assign to bulls. As has always been the case, bulls with desirable performance values will be worth the most money.

THE DEFINITION OF VARIOUS EPD

Breeding associations will differ as to what EPD they generate and report. The following is a description of some of these EPD:

Birth Weight--Indicates the relative size at birth of calves by a sire as compared to the average bull included in the evaluation (expressed in pounds).

Weaning Weight--Indicates the relative weight at 205 days of age of calves by a sire as compared to the average bull of the evaluation who was a weaning weight EPD of 0.0 (expressed in pounds).

Yearling Weight--The relative weight at 365 days of age of calves produced by a sire as compared to calves produced by the average bull of the evaluation with a yearling weight EPD of 0.0 (expressed in pounds).

Milk--The difference in average weaning weight produced by a bull's daughter which is due to her milking ability. Expressed as pounds of calf, not pounds of milk.

Total Maternal--Expressed in pounds, this indicates the ability of the bull's daughter to wean heavier calves. This includes 1/2 of a bull's weaning weight EPD plus his milk EPD.

Gestation Length--Data reported in days compares gestation length of a sire's progeny to the average gestation length of the progeny of all sires in the evaluation.

Calving Ease Direct--Reported as a ratio, this indicates the relative ease with which a bull's calves are born to first-calf heifers. Ratios greater than 100 indicate below average calving ease.

Maternal Calving Ease or Calving Ease Daughter--Reported as a ratio indicates the relative ease with which a bull's daughters calve as first-calf heifers. Values greater than 100 indicate above average calving ease.

ILLINOIS
INTENSIVE GRAZING MANAGEMENT
'89 UPDATE

Tom Saxe, Area Livestock Adviser

Intensive Grazing Management (IGM) is a process of planned rotational grazing which affords maximum satisfaction to the requirements of both forage and animal. IGM is implemented by a short grazing period (e.g., 3 days) followed by a longer rest period (e.g., 30 days) on a given area of pasture. It utilizes a large number of paddocks (e.g., a pasture divided into 11 smaller units) so the animal has access to grazeable forage at all times during the grazing season. This grazing concept maximizes the quantity of forage harvested by reducing trampling losses. This improves beef production efficiency by spreading fixed costs over more pounds of production.

In late 1987, University Extension employees Jim Kaiser, Tom Saxe, Jim Ahrenholz, Bob Frank, and Mike Plumer designed a three year project to investigate and demonstrate IGM technology. A project proposal was written and program support was solicited. Co-sponsors providing multi-year cash grants are: Illinois Beef Council, Illinois Forage and Grassland Council, and Egyptian Livestock Association. Supporting sponsors supplying animal health products, fencing materials and other beef related supplies are: IMC/Ralgro, MSD/AgVet, American Cyanamid, Syntex Corporation, and Gallagher Power Fencing.

PROJECT OBJECTIVES

A broad ranging list of objectives was formulated by the committee:

1. to demonstrate advantages of IGM
2. to teach the concepts involved in IGM
3. to teach producers and educators the agronomic and animal husbandry technology to enhance a successful IGM experience
4. to measure and document results of IGM demonstrations
5. to develop, duplicate, and distribute IGM management guidelines
6. to conduct IGM field days and seminars for producer orientation
7. to develop cow path soil erosion control methodology through IGM practices

DEMONSTRATION COOPERATORS

Seven cooperator farmers initiated demonstrations in 1988. Four utilized stocker animals. They were Curt and Bruce Dean at Ava, Lester Saxe at Thompsonville, Keith Glasco at Cobden, and Ed Billingsley from Goreville. Three cow/calf demonstrations were conducted by Joe Hayes at Marion, Walter Bollmann at Ava, and Carl Woods from Anna. The results are printed in 1989 - 90 Winter Beef Meeting Proceedings.

New cooperators for 1989 were: Warren Dannehold at Waterloo, Ernie Duckworth at Benton, Duane Smith at Allendale, David and Edgar Bremer at Metropolis, David and Clarence Allbritton at Belknap, and John Rueter from St. Libory.

Cooperators conducting demonstrations for the first time in 1990 are: Greg Wells at Annapolis, Larry Ruhl at Fairfield, John Woodcock at Valmeyer, Keith Ellis from Dongola, Rich Hunter from Moweaqua, and Chip Unsicker from Peoria. Results of 1990 will be available at their completion.

'89 ANIMAL PERFORMANCE HIGHLIGHTS

The 41 acre **BILLINGSLEY** demonstration was largest in terms of acreage. This cow/calf program measured production from stock-piled Fescue: Lespedeza from September 18 through December 24. It yielded a low of 260 pounds of adjusted beef per acre. But, during the short 96 day fall grazing season produced a very respectable 2.7 pounds of adjusted beef per acre per day.

BREMER BROTHERS had a mixture of winter born cow/calf pairs and yearling stockers. The effectively reduced stocking rate by removal of the cows at mid season. This demonstration started earliest on April 6. An early start is one key to increasing pounds of beef per acre as well as keeping growth of cool season grasses under control. Early season animal performance was good but tailed off the last half, e.g., yearling steers gained 1.4 from April 6 to July 6, then slipped to .99 pounds per head per day from July 6 to October 10.

The **BOLLMANN** demonstration was basically cow/calf. Animal performance increased over the preceding year whereas most repeat cooperators realized reduced individual gains. Adjusted beef per acre was up 189 pounds. Cows gained .67 pounds per day faster. Calves ADG was .11 greater in '89 as compared to '88. And, pinkeye was not a problem this season. The latter observation may have contributed to the greater gains. the alleviation of the pinkeye problem was felt to be due to eliminating barn access where ammonia buildup irritated eyes in '88. Bollmann's 637 pounds of adjusted beef per acre was highest amongst cow/calf demonstrations.

DEAN FARM was a second year cooperator whose 653 pounds of adjusted beef per acre with stocker heifers was good but below the 768 recorded in 1988. ADG was also reduced .24 pounds from '88. Dean's project was apparently hampered by wild animals which stampeded the cattle on several occasions presenting management problems of regrouping cattle and reconstruction of fences.

WARREN DANNEHOLD had a 111 day grazing season. The new o-till seeding of alfalfa was beleaguered by alfalfa weevils and weed pressure. Dannehold's fleshy 648 pound stockers only gained 1.13 pounds per day but still produced a very respectable 503 pounds of adjusted beef per acre. Plans are to start earlier in 1990.

The **DUCKWORTH** demonstration showed excellent results during the first half of the grazing season. A new seeding, dry weather and drouthy soils took their toll in the last half of the summer. Duckworth was the only cooperator who exercised daily rotation and demonstrated that the animals could harvest almost 100% of the forage produced. Utilization to this extent reduced animal performance and indicated the need to reduce stocking rate and/or offer additional supplemental feed during periods of drouth.

JOHN RUETER demonstrated a sequential grazing concept in addition to Intensive Grazing Management. He rotationally grazed Fescue: Ladino from April 16 to June 12. He sequentially moved to Sudax: Alfalfa from June 12 to September 28. Then

he sequentially moved back to the Fescue: Ladino from September 28 to November 10. The respective ADG's for the three periods (Spring, Summer, Fall) were 2.02, 1.23, and 1.65 pounds. The sum of the Fescue: Ladino yielded 495 pounds of beef per acre with 100 days of grazing. The mid season 108 days on Alfalfa: Sudax produced 640 pounds of gain per acre. The cattle showed a taste preference for Sudax as indicated by grazing habit.

SAXE FARM was a second year cooperator. Their adjusted beef per acre increased from 306 in 1988 to 719 pounds in 1989. This occurred as a result of 14.8 inches of rainfall in '89 compared to 7.25 inches in '88. Saxe Farm effectively reduces stocking rate per acre during the dry part of the summer by enlarging paddock size by about 100%. The paddocks are simply extended onto areas of the pasture where hay was harvested earlier in the season. The harvested hay accounted for 306 pounds of the adjusted beef per acre equivalent.

SUGARTREE RANCH was tops this year with 959 pounds of adjusted beef produced per acre. The 16 acre demonstration carried 101 stockers during 131 days of grazing. Rainfall totaled 23.9 inches during the season with 8.1 and 5.9 respectively coming in the critical July and August periods. This enhanced forage production which garnered 7.3 pounds of adjusted beef per acre per day. Average daily gain was 1.29 pounds on steers averaging 508 pounds.

The **CARL WOODS** project improved over last year. It supported 122 days of grazing in 1989 compared to 73 in 1988. Increased carrying capacity was due mostly to an overseeding of Lespedeza into the Fescue pasture. Adjusted beef per acre was higher by 131 pounds at a respectable 398 pounds per acre for the cow/calf demonstration. Individual animal performance was lower this year as it was for most second year demonstrations. But, Woods' 463 adjusted Animal Unit Days per acre was tops amongst all 1989 cooperators.

See Table 1 for further animal performance details.

Table 1. Animal Performance Details

Cooperator	Acres	Days	No. Head	ADG	Adj. Beef/Acre ⁽¹⁾
Billingsley	41	96	68 cows	.73	260
			62 calves	1.37	
			3 heifers	1.20	
Bollmann	6.9	164	10 cows w/calf	.78	637
			10 calves	1.74	
			1 bull	1.94	
			2 cows	2.05	
			1 steer	1.97	
Bremer	21	187	19 cows w/calf	.49	598
			19 calves	2.10	
			30 steers	1.17	
			12 heifers	.96	
			15 calves	.98	
Dannehold	3.5	111	16 stockers	1.13	503
Dean	15	136	90 stockers	1.23	653
Duckworth	8	161	12 cows	.06	324
			12 calves	1.45	
			1 bull	-.92	
Rueter	14.2	208	24 stockers	1.54	626
Saxe	12	152	30 stockers	1.37	719
Sugartree	16	131	101 stockers	1.29	959
Woods	7	122	14 cows w/calves	-.51	398
			14 calves	1.37	
			4 cows w/o calves	.92	
			1 bull	-.56	
			2 stockers	.92	

⁽¹⁾ Beef per acre was adjusted to account for supplemental feed fed and/or hay harvested from the project area.

ECONOMIC ANALYSIS

An economic analysis is made each year by Region 7 Farm Management Specialist Dr. James Ahrenholz. The 1989 economic summary is presented in Table 2.

Table 2
1989 ECONOMIC SUMMARY
Intensive Grazing Management Demonstration

<u>Farm</u>	<u>Animals</u>	<u>Days</u>	<u>Weight</u>	<u>Cost/lb.⁽¹⁾ Beef Prod.</u>
Dannehold	16 stockers (11S,5H)	111	650	.75
Dean	90 stocker heifers	136	505	.59
Rueter	25 stockers (10S,15H)	208	400	.34
Saxe	30 stocker heifers	152	515	.47
Sugartree	101 stockers (97S,4H)	131	420	.37
Billingsley	62 calves	96 @ 43d		
		22 @ 71d		
		20 @ 96d	275	
	68 cows	20	865	.45
	3 bred heifers	96	760	
Bollmann	10 cows/10 calves	164	1105/pr	
	2 cows	50	975	.36
	1 bull	62	1400	
	1 steer	68	715	
Bremer	19 cows/19 calves	91	1500/pr	
	30 steers	187	625	.36
	12 heifers	187	560	
	15 calves	96	515	
Duckworth	12 cows/12 calves	151	995/pr	.77
	1 bull	151	1225	
Woods	14 cows/14 calves	122	1120/pr	
	4 bred cows	122	1125	.66
	1 bull		910	
	2 stockers		715	

⁽¹⁾Reflects only costs incurred during the project period thus would not include year round costs of the cow/calf herd.

EPD GROUP RANKING

Dave Seibert
Area Livestock Adviser

EPD's (Expected Progeny Differences) are an extremely powerful tool for purebred and commercial cow-calf producers to make genetic changes in their herd. However, many cow-calf producers have trouble understanding what the specific numbers mean and how to use them.

Thus, for the 1990 and 1991 Illinois Performance Tested Bull Sale, held during the Winter Beef Expo in Springfield, a new method of EPD Group Ranking has been initiated. This concept ranks sale bulls within a breed for the four traits of birth weight, weaning weight, yearling weight, and maternal milk. These rankings reflect each bull's EPD ranking within its breed for a similar birth year.

WHY GROUP RANKINGS?

Group Ranking was implemented to assist the commercial bull buyer to: (1) sort bulls within a breed, and (2) identify bulls for different situations.

First, Group Ranking allows cow-calf producers to sort bulls within a breed without having to know the specific EPD numbers. This is especially important since the average and range of a trait for a breed continually changes from year to year as more performance information is added. Thus, with Group Ranking, the cow-calf producers can easily identify where a bull ranks within his breed for a trait.

Secondly, Group Ranking helps the cow-calf producers identify bulls for a specific PROGRAM, ENVIRONMENTAL CONDITION or OBJECTIVE.

- a. Your PROGRAM can be a cow-calf operation that sells calves as feeder cattle, backgrounded yearlings, finished cattle or possibly as purebred seedstock. With each of these programs, you might emphasize different trait EPD's. Also, your program is affected by the amount of observation and assistance provided at calving which would directly affect the level of birth weight EPD's that are acceptable.
- b. ENVIRONMENT (temperature and rainfall) is greatly different from the extreme southern to the northern part of Illinois. Likewise, the other environmental factors (level of nutrition, management, etc.) can be equally as varied between two operations located next to one another. Whether you provide an EXCELLENT ENVIRONMENT for your cow herd (high quality summer pasture and hay or corn silage in winter) or a POOR ENVIRONMENT (un-

improved brush pasture and poor quality forage or crop residue in the winter), will greatly affect the level of EPD's (especially maternal milk) that you purchase for your herd.

- c. OBJECTIVES are the traits that you would like to improve or complement in your herd. Do you want to purchase a bull to INCREASE, MAINTAIN or DECREASE birth weight, weaning weight, yearling weight, milk production, frame size, scrotal size (age at puberty), etc?

Evaluation of your cow-calf herd's STRENGTH/WEAKNESS, ENVIRONMENT & PROGRAM and then matching the EPD's of the available bulls are what will make your use of EPD's PAY OFF.

1991 PERFORMANCE TESTED BULL SALE GROUP RANKING SYSTEM":

EPD Group Ranking System

Rank	% breed at each Level	EPD Trait Level of Performance			
		Birth	Wean	Year	Milk
AA	0 to 5%	Lightest	Highest	Highest	Most
A	6 to 20%	.....	.....	.....	.....
B	21 to 40%	.....	.....	.....	.....
C	41 to 70%	moderate	moderate	moderate	moderate
D	71 to 90%	.....	.....	.....	.....
E	91 to 100%	heaviest	lowest	lowest	least

The EPD Group Ranking System that will be used at the 1991 Illinois Performance Tested Bull Sale is divided into FIVE different groups. Each of these groups represents what percentile a bull ranks as compared to bulls for a similar birth year.

WHAT DOES EPD GROUP RANKING MEAN??

For BIRTH WEIGHT those bulls with an AA, A & B Ranking would be expected to sire calves with the LIGHTEST birth weight and should probably be used on replacement heifers. Bulls with C Ranking for birth weight are MODERATE for their breed, while D and E Ranking will result in calves with the HEAVIEST birth weight and should be used on mature cows. One consideration that must be made is that EPD's are within breed, and breed calving differences should be considered.

For WEANING & YEARLING WEIGHT those bulls with an AA, A & B Ranking would be expected to sire calves with the HEAVIEST weights. Bulls with C Ranking are MODERATE for their breed, while D and E Ranking will result in calves with the LOWEST weight gains.

It is extremely important that the level of milk you need in your herd must MATCH THE ENVIRONMENT (level of nutrition and MANAGEMENT) and complement the current milk production level of your herd. Milk EPD's are ranked from MOST (AA & A) to least (E), with neither of these being most desirable for ALL situations. Examples for level of milk might include the following:

a. EXCELLENT ENVIRONMENT & MANAGEMENT (high quality summer pasture and hay or corn silage in winter) - B, A or possibly AA or C.

b. POOR ENVIRONMENT & MANAGEMENT (unimproved brush pasture and poor quality forage or crop residues in the winter) - C or possibly D.

c. TERMINAL SIRES (level of milk production in offspring daughters are not important since all offspring go to market) - E or any other level is acceptable as long as HIGH level of WEANING & YEARLING WEIGHT EPD's.

DIFFERENCES BETWEEN BREEDS:

Obviously there are Levels of Performance Difference between BREEDS. Therefore, B in one breed (for a trait) does not equate to the same number of pounds as a B in another breed. However, a B of one breed (for a trait) does mean that that bull falls into the same percentage Group Ranking as all the other B's in the same breed.

SUMMARY

Selecting a Herd Sire is like purchasing seed corn or any other genetics. Time spent analyzing your specific situation (Program, Environment and Objective) prior to attending a bull sale might be the most important part of buying your next bull.

Fencing System Comparisons

Types of fencing systems

Non-electric

Woven-wire plus a top barb, five-strand barbed wire, and the "New Zealand" type smooth wire fence materials are commonly used as non-electric perimeter fences in Illinois. Woven-wire and barbed wire fences are very familiar, as they have been used in the state for many years. Smooth wire fencing has not been available for as long, and did not enjoy immediate acceptance when it was first introduced since it requires some specialized equipment and methods for installation.

Smooth wire fence relies on the high tensile strength of special galvanized steel wire to retain cattle. One or more tensioning springs on each strand of wire keeps the fence tight, so that cattle rubbing on the wires do not permanently deform the fence as they do a woven-wire or a barbed wire fence. Several strands of wire are used; eight or ten strands is a common configuration, with ten strands preferred. Long staples are used to hold the wires to the line posts, and the staples are hammered to the posts in such a way that the wires can slip back and forth through the staples. Because there is so much force on the posts in a smooth-wire fence, conventional tamped-earth post embedment normally is not suitable. Treated-wood posts are used, driven small-end down using a tractor-mounted post driver. Posts can be placed farther apart than in a woven-wire or barbed wire fence.

Electric

Multiple-strand perimeter fence

A perimeter electric fence of heavy-gauge high-tensile galvanized wire (such as 12-1/2 gauge) has the same life expectancy as woven-wire, or greater. As in a non-electric smooth-wire fence, several strands are used and each strand has its own tensioning spring.

Smooth-wire paddock fence

Where a pasture is divided into segments, or paddocks, single strands of wire are used to form the division fences. High-tensile wire can be used to advantage for longer runs, due to the wire's strength and good electrical conductivity compared to light-gauge wire. However, softer steel wire is easier to work with and costs less than high-tensile, and therefore has good acceptance among beef producers. Innovative posts, end

Material adapted for the 1990-91 Proceedings, Winter Beef Meetings, University of Illinois Cooperative Extension Service, by Ted Funk, Area Agricultural Engineer, Effingham, IL.

insulators, standoff insulators, and drive-over gates have been developed to make single- and multiple-strand smooth-wire paddock fences very labor-efficient and cost-effective.

Flexible line paddock fence

For temporary electric fencing of paddocks where cattle are accustomed to electric fence, flexible strand materials can be used to reduce labor and materials costs. Flexible strand materials are usually plastic twine or tape, with some very fine strands of stainless steel wire woven into the plastic to carry the electric current. Lightweight fence posts made of insulating materials (fiberglass or other plastic) eliminate the need for separate insulators and make the fence very easy to put in place and move when the paddock boundaries need to be changed.

Bases for comparisons

Economic

Initial investment

Although component prices for fencing vary with time and throughout the region, some typical costs are presented here to stimulate comparison. Initial investment costs for the various types of fences are as follows:

Fence type	Fence Cost, \$/100 ft.		
	Materials	Labor	Total
Woven wire + 1 barb	70.00	25.00	95.00
Five-strand barb	44.00	27.00	71.00
Ten-strand high-tensile	55.00	20.00	75.00
Three-strand high-tensile electric	20.00	4.00	24.00
One-wire portable electric	6.00	--	6.00

Among perimeter fences, the three-strand high-tensile electric fence materials cost about one-fourth as much as woven wire, and about a third that of five-strand barbed wire. The cost for non-electric ten-strand high-tensile fence lies between barbed wire and woven wire.

One-strand electric fence has no competitors for temporary fencing. Solid wire is preferred over flexible materials for long runs (greater than one-half mile); otherwise the flexible material wins out because of lower labor costs.

Installation equipment

Multiple-strand smooth-wire fence construction requires certain special tools as a minimum: a tractor-mounted fence post driver, a "spinning jenny" wire unrolling mechanism, and crimping tools for splicing the wire and installing braces.

Labor

Cost of labor for installing perimeter fence favors the three-strand electric fence, and even the ten-strand non-electric high-tensile fence requires less labor than the more traditional woven-wire and barbed fences.

Labor for installing temporary electric fencing is very low compared to perimeter fences, and is not considered a factor of fence length here.

Annual ownership cost

Annual cost of ownership includes depreciation, interest on investment (8% per year assumed here), and maintenance. Note that the useful life of the high-tensile fence is extended beyond that of other steel products, assuming that you buy domestic steel wire with extra-heavy galvanized coating.

Fence type	Useful life	Annual cost, % of initial cost
Woven wire + 1 barb	20 years	8%
Five-strand barb	20 years	8%
Ten-strand high-tensile	30 years	3%
Three-strand high-tensile electric	30 years	6%

Performance

Several performance factors enter into the decision of what fence system to build:

Livestock retention

Any of the perimeter fences can do an adequate job of holding cattle. However, it should be remembered that an electric fence is primarily a psychological barrier, and a non-electric fence is a physical barrier. An electric fence will do a better job of holding cattle that have been accustomed to it than will a non-electric fence, whereas a non-electric fence presents a more formidable barrier to cattle that are unfamiliar with electric fence. Electric fencing systems have less wear from cattle pressure simply because the animals respect the fence and keep their distance at all times.

Wildlife control: deer, coyote

Deer pose a menace to temporary electric fences because the animals usually attempt to go under or through the wire rather than jump over. High-tensile wire is less susceptible to damage and more satisfactorily repaired when damaged than is soft steel wire. Certain perimeter electric fence construction types have been shown to be effective in keeping deer out of pastures.

Coyotes learn to dig under perimeter fences, whether electrified or not. Use of a grounded "trip wire" just outside the fence and near the ground has been shown to be useful in preventing coyotes from crawling under fences. Alternating hot and grounded wires in the fence also reduces the incidence of coyotes jumping through the fence.

Animal and/or human injury

Barbed wire fences are notorious for snagging hides and cutting the legs of animals that insist on tangling with the fence. Smooth wire non-electric high-tensile fences can cut legs, but the problem is rare in fences that have a large number of strands. For non-electrified perimeter fences ten strands are recommended.

Electric fences that are charged by a good-quality controller generally do not pose a hazard to livestock or humans; the extremely short duration of the electric shock gives time for the affected animal or person to let go of the fence and back away. Any fence construction that allows an animal or human to be caught in the fence is hazardous, however. For this reason, barbed wire fences should not be electrified.

"Weed-burner" controllers that have a long-duration shock should never be used on any electric fence. They are a fire and safety hazard.

Visibility

Single-strand temporary electric fences can be difficult to see under some circumstances. The flexible strand materials are made of brightly-colored plastics and are therefore much more visible to humans and animals against most vegetative backgrounds than are galvanized wire materials.

Esthetics

While woven-wire and multiple-strand barbed wire fences are viewed as traditional and esthetically acceptable, all the perimeter fences depend on a good quality layout and installation for a pleasing addition to a farm landscape. High-tensile wire installations do not sag with age and cattle pressure as woven-wire and barbed wire do, since there are built-in tensioning springs. Corrosion is less of a problem with high-tensile wire that has extra-heavy galvanized coating.

Maintenance

Restretching of fencing is sometimes required on perimeter fences, especially in wooded areas where trees fall across the fenceline. Smooth-wire high-tensile fencing is much easier to repair after tree removal. Wire splicing of smooth wire is much quicker and retains the strength of the wire through the splice, compared with repairs to barbed or woven wire.

Performance checks on electric fencing systems are required periodically, and the use of a special voltmeter (cost: \$75 to \$100) is recommended. Cattle will test the fence inadvertently on occasion, and a "cold" electric fence will eventually be breached.

Removal of weeds and crops from a fenceline is somewhat easier in high-tensile wire fence systems because there are no vertical wire stays in the fence; in addition, wider post spacings are used than with woven-wire fence.

Fence controller maintenance on electric fences is mainly limited to periodic checks of the voltage on the fence, except in the case of battery-operated fence controllers that require recharging or replacement of batteries. Solar-powered fence controllers use solar energy to recharge the batteries, decreasing or eliminating the need to switch batteries that have run low.

GROWTH OF SPRING AND FALL CALVED HEIFERS GRAZING HIGH OR LOW
ENDOPHYTE INFECTED TALL FESCUE PASTURES

DIXON SPRINGS AGRICULTURAL CENTER

GENE M. ZINN and R. S. OTT

SPRING CALVED HEIFERS:

Twenty eight yearling beef heifers, calved in the spring of 1989, were divided by weight into three groups. Animals in each group were randomly allotted to a high (>75%) endophyte (HE) or a low (<25%) endophyte (LE) infected tall fescue pasture. Animals were weighed at 28 day intervals for 112 days and the average daily gain (ADG) was computed. The heifers grazing the HE pastures had an ADG of .46 kg/day (1.02 lb/day) while the LE group had an ADG of .64 kg/day (1.41 lb/day) which is a 38% increase (Table 1).

FALL CALVED HEIFERS:

Thirty one beef heifers, calved in the fall of 1989, were divided by weight into three groups. Animals in each group were randomly allotted to HE or LE tall fescue pastures as previously described. Animals were weighed at approximately 28 day intervals for 138 days and the ADG was computed. The heifers grazing the HE fescue pastures had an ADG of .25 kg/day (.56 lb/day) while the LE pasture group had an ADG of .44 kg/day (.96 lb/day) which is a 71% increase (Table 2).

These data indicates animal age may be a factor influencing ADG by animals grazing HE infected tall fescue pastures.

TABLE 1. 1990 HIGH & LOW ENDOPHYTE FESCUE PASTURE STUDY USING HEIFERS CALVED THE PREVIOUS SPRING.

CAF ID NUMBER	REP NO	FESCUE ENDOPHTE	CF BIRTH --DATE--	--CALF-- --BREED--	WNG WWT	08-May WGHT	05-Jun WGHT	03-Jul WGHT	31-Jul WGHT	28-Aug WGHT	WNG RAT	R K	OVERALL ADG
9295	1	HIGH	2-24-89	AN	525	720	750	795	795	820	111	2	0.89
9308	1	HIGH	3-4-89	HP-AN	419	630	710	720	750	735	96	4	0.94
9309	1	HIGH	3-5-89	HP-AN	500	675	720	765	795	815	109	2	1.25
9322	1	HIGH	3-22-89	AN-HP	454	700	800	810	850	840	107	2	1.25
9346	1	HIGH	4-8-89	AN	363	660	725	745	755	740	91	5	0.71
AVG WT ADG					452	677	741 2.29	767 0.93	789 0.79	790 0.04			1.01
9294	1	LOW	2-23-89	BN-AN	463	645	720	745	765	785	106	2	1.25
9301	1	LOW	2-26-89	AN-HP	493	700	775	805	830	830	114	2	1.16
9304	1	LOW	2-28-89	AN	520	700	790	821	845	865	120	1	1.47
9344	1	LOW	4-7-89	HP-HP.SM	455	680	715	795	840	850	118	1	1.52
AVG WT ADG					483	681	750 2.46	792 1.48	820 1.02	833 0.45			1.35
9281	2	HIGH	2-6-89	BN-AN	450	640	680	720	755	770	97	4	1.16
9293	2	HIGH	2-22-89	BN-AN	425	585	660	685	730	755	98	4	1.52
9306	2	HIGH	3-1-89	BN-AN	434	570	640	660	695	710	102	2	1.25
9307	2	HIGH	3-3-89	AN-HP	390	580	650	655	680	695	89	6	1.03
9354	2	HIGH	5-8-89	HP-JE.AN	375	580	625	625	670	660	113	2	0.71
AVG WT ADG					415	591	651 2.14	669 0.64	706 1.32	718 0.43			1.13
9297	2	LOW	2-25-89	HP-SM.HP	453	625	690	720	730	775	105	2	1.34
9305	2	LOW	3-1-89	BN-HP	428	566	655	705	720	775	92	5	1.87
9310	2	LOW	3-7-89	BN-AN	405	580	655	705	735	780	98	4	1.79
9327	2	LOW	3-23-89	HP-AN.HP	406	590	650	695	710	745	96	4	1.38
9347	2	LOW	4-11-89	AN	392	580	625	670	695	725	100	3	1.29
AVG WT ADG					417	588	655 2.39	699 1.57	718 0.68	760 1.50			1.53
9284	3	HIGH	2-12-89	BN-AN.SM	366	505	580	595	610	615	83	6	0.98
9285	3	HIGH	2-12-89	BN-AN	394	545	600	625	655	665	88	6	1.07
9343	3	HIGH	4-7-89	AN	394	540	605	615	625	630	99	3	0.80
9351	3	HIGH	4-17-89	AN-HP	392	555	615	640	660	655	102	3	0.89
9356	3	HIGH	5-28-89	AN-AN.HP	342	550	610	635	655	640	115	1	0.80
AVG WT ADG					378	539	602 2.25	622 0.71	641 0.68	641 0.00			0.91
9299	3	LOW	2-25-89	AN	368	525	605	628	660	690	87	6	1.47
9317	3	LOW	3-18-89	HP-AN.HP	412	545	615	630	655	680	95	5	1.21
9324	3	LOW	3-23-89	HP-AN	370	560	630	669	690	720	87	6	1.43
9348	3	LOW	4-12-89	AN	370	555	635	656	685	705	95	5	1.34
AVG WT ADG					380	546	621 2.68	646 0.88	673 0.96	699 0.94			1.36

TABLE 2. 1990 HIGH & LOW ENDOPHYTE FESCUE PASTURE STUDY USING HEIFERS CALVED THE PREVIOUS FALL.

CAF ID NUMBER	REP NO	FESCUE ENDOPHYTE	CF BIRTH --DATE--	--CALF-- --BREED--	WNG WGT	19-Apr WGHT	15-May WGHT	12-Jun WGHT	10-Jul WGHT	07-Aug WGHT	04-Sep WGHT	WNG RAT	R K	OVERALL ADG
9370	1	HIGH	9-11-89	AN-AN.HP	433	510	486	495	535	565	579	111	2	0.50
9380	1	HIGH	9-14-89	AN	457	540	507	525	555	585	629	119	1	0.64
9397	1	HIGH	9-24-89	AN	425	515	481	495	500	540	553	116	1	0.28
9400	1	HIGH	9-27-89	AN	457	525	511	525	560	590	621	122	1	0.70
9408	1	HIGH	10-5-89	AN-AN.SM	433	515	498	495	525	550	576	124	1	0.44
AVG WT ADG					441	521	497 -0.94	507 0.37	535 1.00	566 1.11	592 0.91			0.51
9367	1	LOW	9-9-89	AN	435	520	505	530	540	565	610	106	3	0.65
9371	1	LOW	9-11-89	AN-SM.HP	456	520	527	555	590	630	657	116	1	0.99
9383	1	LOW	9-15-89	AN	420	475	478	475	495	515	556	106	3	0.59
9389	1	LOW	9-20-89	AN-SM.HP	395	515	427	565	605	640	695	105	3	1.30
9392	1	LOW	9-22-89	AN-SM.HP	427	525	512	530	580	600	657	115	2	0.96
AVG WT ADG					427	511	490 -0.82	531 1.47	562 1.11	590 1.00	635 1.61			0.90
9368	2	HIGH	9-9-89	AN-CH	397	450	442	460	485	505	540	97	4	0.65
9374	2	HIGH	9-12-89	AN	445	510	512	520	525	533	559	111	2	0.36
9385	2	HIGH	9-16-89	AN-AN.SM	390	465	464	485	505	530	569	102	3	0.75
9399	2	HIGH	9-26-89	AN	410	495	485	510	515	535	562	108	3	0.49
9405	2	HIGH	10-2-89	AN	375	445	435	460	495	525	558	102	3	0.82
AVG WT ADG					403	473	468 -0.21	487 0.69	505 0.64	526 0.74	558 1.14			0.61
9361	2	LOW	9-7-89	AN	375	455	453	485	485	510	540	91	5	0.62
9372	2	LOW	9-11-89	AN-AN.SM	372	455	466	510	525	565	611	92	5	1.13
9376	2	LOW	9-13-89	AN-JE.HP	398	465	470	510	540	560	610	103	3	1.05
9388	2	LOW	9-18-89	AN	354	445	457	490	500	525	570	94	4	0.91
9401	2	LOW	9-29-89	AN-JE.AN	395	505	482	505	550	580	638	110	2	0.96
AVG WT ADG					379	465	466 0.02	500 1.23	520 0.71	548 1.00	594 1.64			0.93
9359	3	HIGH	9-6-89	AN-AN.HP	368	450	451	465	490	500	538	93	5	0.64
9379	3	HIGH	9-13-89	AN	365	440	455	475	485	510	527	91	5	0.63
9393	3	HIGH	9-22-89	AN	341	440	410	425	465	485	525	92	5	0.62
9404	3	HIGH	10-1-89	AN	357	430	418	425	455	475	510	97	4	0.58
9407	3	HIGH	10-5-89	AN-SM.AN	352	435	423	435	470	475	509	102	4	0.54
9412	3	HIGH	10-29-89	AN-HP	357	440	440	440	455	465	499	117	1	0.43
AVG WT ADG					357	439	433 -0.24	444 0.40	470 0.92	485 0.54	518 1.18			0.57
9358	3	LOW	9-5-89	AN-AN.HP	341	425	440	478	510	550	580	86	5	1.12
9377	3	LOW	9-13-89	AN	355	440	453	480	515	545	570	92	5	0.94
9384	3	LOW	9-16-89	AN	332	455	455	505	525	597	635	84	5	1.30
9391	3	LOW	9-22-89	AN-HP	343	410	418	455	480	525	545	93	4	0.98
9403	3	LOW	9-30-89	AN	330	455	445	475	520	547	575	97	4	0.87
AVG WT ADG					340	437	442 0.20	479 1.30	510 1.12	553 1.53	581 1.01			1.04

A GUIDE FOR ESTIMATING SEASON LONG PASTURE DAYS IN ILLINOIS

C. J. (Jim) Kaiser
Forage Production and Pasture Management

The two most powerful tools producers have for influencing the level of animal output under grazing are (1) system of grazing management and (2) concentration of animals per unit area (stocking rate). The concept of grazing management implies decision-making. Profitable decision-making requires knowledge about pasture species, animal response desired relative to the market, and the pasture-animal interaction.

Knowledge of the carrying capacity of a pasture as animal unit days (the amount of forage needed to maintain one mature cow or 1,000 pounds of live weight for one day) can be useful in planning for forage establishment (Table 1) or for planning the season long grazing (Table 2) of established pastures. Yield losses of continuously grazed pastures is assumed to be 33 percent of the dry matter grown. Animal unit pasture day (24 pounds of dry matter) per acre may also be related to hay produced per acre by the use of the following formula.

Tons hay (dry matter) grown $\times .67$ = tons hay equivalent

Tons hay equivalent $\times 83.33$ = animal unit pasture days

Animal unit pasture days $\times 0.012$ = tons hay equivalent

Tons hay equivalent $\times 1.49$ = Tons hay (dry matter) produced

The animal unit days may be determined for legume grass mixtures by estimating the percent of each grass and legume components and multiplying the it by the estimated animal unit pasture days. The sum of these values may be used as the estimated animal unit pasture days for the mixture.

The values are estimates only of pastures continuously grazed. Intensively grazed pastures consisting of eleven or more paddocks grazed on a 33 day cycle of 30 days rest per paddock and 3 days of grazing are expect to be higher in estimated grazing days, hay equivalent and hay yields.

Table 1. Estimated Animal Unit Pasture Days, Hay Equivalent, and Hay Yields per Acre for the Growing Season of Selected Pasture Crops under continuous grazing management.

Pasture Species	Animal Days	Hay equivalent Tons	Hay Tons
Alfalfa	170	2.04	3.04
Red clover	135	1.62	2.41
Large white clover	77	0.92	1.38
Birdsfoot trefoil	94	1.13	1.68
Sweet clover	95	1.14	1.70
Sericea lespedeza	96	1.15	1.72
Lespedeza	65	0.78	1.16
Perennial cool season grasses			
Kentucky bluegrass	88	1.06	1.57
Orchardgrass	155	1.86	2.77
Tall fescue	168	2.02	3.00
Reed canarygrass	139	1.67	2.49
Smooth brome	154	1.85	2.75
Perennial ryegrass	60	0.72	1.07
Timothy	82	0.98	1.47
Redtop	67	0.80	1.20
Perennial warm season grasses			
Bermudagrass	118	1.42	2.11
Switchgrass	110	1.32	1.97
Eastern gamagrass	120	1.44	2.15
Big bluestem	105	1.26	1.88
Indiangrass	100	1.20	1.79
Annual summer grasses			
Sorghum x sudangrass	98	1.18	1.75
Pearlmillet	97	1.16	1.73
Spring seeded forages			
Spring rape	50	0.60	0.89
Spring oat	55	0.66	0.98
Fall seeded forages			
Winter rye	80	0.96	1.43
Fall rape	40	0.48	0.72

Table 2. Estimated Animal Unit Pasture Days, Hay Equivalent, and Hay Yields per Acre for the Growing Season of Selected Pasture Crops under Continuous Grazing Management in Illinois

Pasture Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Days	Tons H E	Tons Hay
Alfalfa	0	0	5	15	30	30	25	25	20	15	5	0	170	2.04	3.04
Tall fescue	0	0	10	25	30	30	12	7	12	22	15	5	168	2.02	3.00
Orchardgrass	0	0	5	25	30	25	15	10	15	20	10	0	155	1.86	2.77
Smooth bromegrass	0	0	5	25	30	30	15	7	12	20	10	0	154	1.85	2.75
Reed canarygrass	0	0	10	25	30	30	25	7	10	2	0	0	139	1.67	2.49
Red clover	0	0	5	15	25	25	25	15	10	10	5	0	135	1.62	2.41
Eastern gamagrass	0	0	0	0	10	30	30	20	20	10	0	0	120	1.44	2.15
Bermudagrass	0	0	0	0	8	24	30	30	20	6	0	0	118	1.42	2.11
Switchgrass	0	0	0	0	20	30	30	15	10	5	0	0	110	1.32	1.97
Big bluestem	0	0	0	0	15	30	30	25	5	0	0	0	105	1.26	1.88
Indiangrass	0	0	0	0	10	15	25	30	15	5	0	0	100	1.20	1.79
Sorghum-sudangrass	0	0	0	0	0	8	30	30	25	5	0	0	98	1.18	1.75
Pearl millet	0	0	0	0	0	5	30	30	25	7	0	0	97	1.16	1.73
Sericea lespedeza	0	0	0	3	10	20	20	18	15	10	0	0	96	1.15	1.72
Sweet clover	0	0	3	15	20	20	10	5	5	15	2	0	95	1.14	1.70
Birdsfoot trefoil	0	0	2	10	20	20	15	10	12	5	0	0	94	1.13	1.68
Bluegrass	0	0	2	15	25	10	5	3	6	15	7	0	88	1.06	1.57
Timothy	0	0	2	15	20	20	5	4	6	8	2	0	82	0.98	1.47
Winter rye	0	0	15	20	0	0	0	0	0	15	20	10	80	0.96	1.43
White clover	0	0	6	15	15	15	5	2	5	10	4	0	77	0.92	1.38
Redtop	0	0	0	12	18	18	5	2	5	7	0	0	67	0.80	1.20
Lespedeza	0	0	0	0	0	7	15	15	15	13	0	0	65	0.78	1.16
Perennial ryegrass	0	0	0	0	15	20	10	5	5	5	0	0	60	0.72	1.07
Spring oat	0	0	0	5	25	25	0	0	0	0	0	0	55	0.66	0.98
Spring rape	0	0	0	0	0	5	15	15	10	5	0	0	50	0.60	0.89
Fall rape	5	0	0	0	0	0	0	0	0	5	15	15	40	0.48	0.72

Tons H E equals Tons Hay Equivalent

FORAGE PRODUCTION

Dr. C. J. Kaiser, University of Illinois Forage Agronomist, headed up the forage production analysis of intensively grazed pastures during 1989. Measurements were taken by farmer cooperators with a forage meter board each time cattle were moved to and from a paddock. Hand clippings were taken monthly during the grazing season to calibrate the meter board. Samples were laboratory tested for dry matter, protein and energy values.

Table 3 lists some general parameters of the forage data:

Table 3. Forage Parameters

<u>Cooperator</u>	<u>Forage Specie</u>	<u>Days Grazed</u>	<u>No. Paddocks</u>	<u>No. Cycles</u>	<u>Tons DM Produced</u>	<u>Tons DM Consumed</u>
Billingsley	TF:Lesp.	96	9	3	6.1	3.6
Bollmann	ALF	161	8	6	5.6	3.0
Bremer	TF:ALF	188	11	6	3.5	2.1
Dannehold	ALF:TF	114	9	4	3.3	1.4
Dean	ALF:OG	146	10	6	5.4	3.5
Duckworth	ALF:OG, TF:RC	171	36	9	6.7	4.1
Rueter	TF:RC, ALF:SdAX	209	6	10	10.2	5.8
Saxe	ALF:TF	153	14	5	6.3	3.1
Smith	ALF	141	12	4	3.5	1.6
Woods	TF:Lesp.	160	12	8	4.7	2.7

FURTHER INTERESTS

Cattlemen who have further questions about Intensive Grazing Management can contact the producer cooperators for additional information. Tom Saxe and Jim Ahrenholz at 618-439-7263 or Jim Kaiser at 217-333-4424 will respond to questions about the Animal Performance, Economic Analysis and Forage Production results, respectively.

MANAGING BEEF REPLACEMENT HEIFERS

Richard K. Knipe

The replacement beef heifer is an extremely important, although sometimes overlooked, segment of the cow herd. Proper development of replacement heifers is a critical part of improving herd productivity. Heifers should grow rapidly, reach puberty early and conceive early for high productivity.

In Illinois, we have an abundance of feed and therefore economics dictate that heifers be bred to calve at two years of age. Therefore, the rest of this paper will work with the assumption that all heifers will be bred at 13-15 months of age.

The management and development of the replacement heifer will be discussed in four phases:

- 1) Pre-weaning
- 2) Weaning to breeding
- 3) Breeding to calving
- 4) Rebreeding the first-calf heifer

Pre-weaning

It is important that replacement heifers weigh at least 450 pounds at weaning and that this growth be normal skeletal and muscle growth, and not a lot of excess body fat. Thus, heifers should be grown on the cow without the use of high energy creep rations. Plane of nutrition and growth rate have been shown to exert significant effects on mammary development and milk production of beef heifers. The general relationship between rate of gain during rearing and subsequent milk production is that both inadequate nutrition (too low rate of gain) and overfeeding (too high rate of gain) can result in reduced milk yields. This relationship has been described in numerous studies in dairy cattle, and has also been demonstrated in beef cattle and sheep.

Early evidence for negative effects of overfeeding beef replacement heifers on their future productivity came from observations that heifers that were heaviest at weaning often weaned the lightest calves. Research at Colorado State shows a cyclic trend in calf weaning weights due to excess milk production. This cycle operated such that heifers (1st generation) from the highest weaning weight group weaned lighter calves. The 2nd generation heifers weaned heavier calves on average, which in turn the 3rd generation heifers weaned lighter calves. The cycle may be explained as follows: 1) High weaning weight heifers are overfed, causing the expected reduction in mammary development, milk production, and progeny weaning weights; 2) Progeny of overfed heifers receive less milk, thus are lighter at weaning, but have normal mammary development and milk production, and therefore wean heavier progeny. These trends then continued over subsequent generations.

It is widely recommended that commercial producers implant nursing calves. Since it is economically beneficial to implant the nursing calf, it becomes necessary to implant calves before the replacements are selected. The question then becomes, "What affect does the implant have on future reproductive performance?" A great deal of research has been done to answer that question, and you can find data to defend any opinion. However, it has been shown that one implant between one month of age and weaning is safe and beneficial and most studies show that the second implant begins to have a negative effect on reproductive performance. It can be argued that increasing the nutritional level

will eliminate the reproductive problems of multi-implanted heifers. However, this also results in increased feed costs to develop this heifer. It is therefore very difficult to justify the cost of implanting the replacement heifer.

Weaning to Breeding

In a well-managed beef operation, heifers are bred three to four weeks prior to the cows to insure they have adequate time to rebreed. In order to have a high percentage of the heifers bred early, 80 to 90% of the heifers will need to have reached puberty by the time they are 12 to 13 months old.

Puberty is the period at which the heifer shows first estrus and ovulation. The age at which the heifer reaches puberty is a function of her body weight and frame size. Heifers need to reach the 550-750 pound weight range in order to begin cycling. As heifer frame size increases so does the body weight requirement for puberty. For example, small frame heifers should reach puberty at 550-600 pounds while large frame heifers may have to weigh 750 pounds.

If your heifers had an average weaning weight of 450 pounds at 7 months of age and you want the heifers to weigh 650 pounds at 13 months, then they must be fed to gain approximately 1.1 pounds per day. Heifers are amazingly tolerant of how and when they gain the weight as long as they do not get too thin or too fat. In this example, it does not matter if the heifers gain 1.1 pounds every day or if she gains 0.5 pounds per day for the first 100 days and then fed to gain 2.0 pounds per day for the next 75. This does make it important that a group of heifers be of uniform frame size if they are to be fed together. If there is great variation in frame size, either the small frame heifers get too fat or the large frame heifers are not heavy enough to begin cycling at 13 months.

When heifers are approximately 12 months of age they should be evaluated for weight, frame, pelvic size, and maturity of reproduction tract. Producers that want to select for growth should be weighing all heifers at this time because yearling weight measurements are the best indicators of growth. This program involves selecting heifers for breeding by size and type, obtaining pelvic measurements, palpating for ovarian development (puberty), and vaccinating for reproductive diseases, all during one processing through the chute. At this time cull heifers can be placed in the feedlot and finished at a relatively young age.

Breeding to Calving

Just having the first calf heifer bred as a yearling does not mean the job is completed. It is extremely important that this heifer continue to grow from breeding to calving. In fact, heifers that weigh 600 to 650 pounds at breeding should gain another 200 to 250 pounds or more before calving. This means that these heifers will have to gain 3/4 to 1 pound per day from breeding to calving.

Generally with spring calving cow herds, these bred replacement heifers will remain on summer grass from breeding until fall. If the quantity and quality of grass is adequate, they should easily achieve a gain of from 1 to 1 1/2 pounds per day. Then in the fall of the year, they would be fed harvested or stored feed until calving, possibly in some cases using the stored feed as a supplement to native grass. During this period of time, it is important to remember what nutrients the bred heifer really needs. Protein is important as the heifer is continuing to gain weight, however, protein is not nearly as important as energy. The following table of work done at the North Platte Experiment Station

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in Nebraska vividly illustrates the fact that energy is the real key nutrient during this period of time. Heifers that were fed an inadequate level of energy required nearly three times as long a period from calving to first estrus and likewise had a markedly reduced conception rate because the heifers were not cycling. As can be noted, however, the ideal combination to use was adequate protein and energy in which the heifers gained nearly 3/4 pounds per day, produced the heaviest calves at birth, had the shortest interval to first estrus, and had the highest conception rates at first service.

EFFECT OF ENERGY AND PROTEIN LEVEL DURING GESTATION ON
PERFORMANCE OF BRED BEEF HEIFERS (Nebraska Data)

	<u>Low Protein Low Energy</u>	<u>Low Protein High Energy</u>	<u>High Protein Low Energy</u>	<u>High Protein High Energy</u>
Winter Weight Change (12/9-4/27)	-11 Lbs.	62 Lbs.	10 Lbs.	117 Lbs.
Calf Weaning Weight (180 Days of Age)	295 Lbs.	308 Lbs.	323 Lbs.	293 Lbs.
Rebreeding Data				
Calving to 1st estrus	142 days	54 days	148 days	51 days
% 1st service conception	67%	38%	50%	83%
% Final conception	38%	75%	29%	86%

Rebreeding the First-Calf Heifer

The first lactation is probably the most critical phase of a beef cow's productive life. This heifer is still growing, producing milk for the calf, and the uterus is preparing for the next pregnancy. Each of these require extra feed and it is very difficult to manage the first-calf heifer if she is with the mature cows. Therefore it is important to separate the heifers from the mature cows for extra management. Again it is important to feed both extra protein and energy, however, the extra energy is more important. An extra 3-5 pounds of corn to the first-calf heifer can go a long way toward getting her rebred by 90-120 days postpartum. Remember that if the heifer calves 30 days before the mature cows we have an extra 30 days to get her rebred.

The critical aspect of feeding the beef cow to rebreed while keeping costs down is to feed to meet the cow's requirements. For example, a 1000 pound two-year old heifer nursing a calf requires 13 pounds of TDN (energy) and 2.1 pounds of crude protein. If you are feeding this heifer good quality hay (15% crude protein) she is probably consuming approximately 20 pounds of dry matter. Therefore she is receiving 3 pounds of crude protein and 11 pounds of TDN. In other words, she

is getting too much protein and too little energy. This heifer is now in a negative energy balance and will be more difficult to rebreed.

Conclusion

The biggest single factor affecting beef cow reproduction performance is nutrition. The young heifer calf needs adequate skeletal and muscle development, but rapid growth will negatively affect milk production. On the other hand the yearling heifer needs more energy to reach an optimum weight in order to reach puberty by 12 months of age. Clearly, the most critical point in the production cycle is the 2-year old heifer that is nursing a calf while still growing and preparing for rebreeding. This is the stage that requires careful management.



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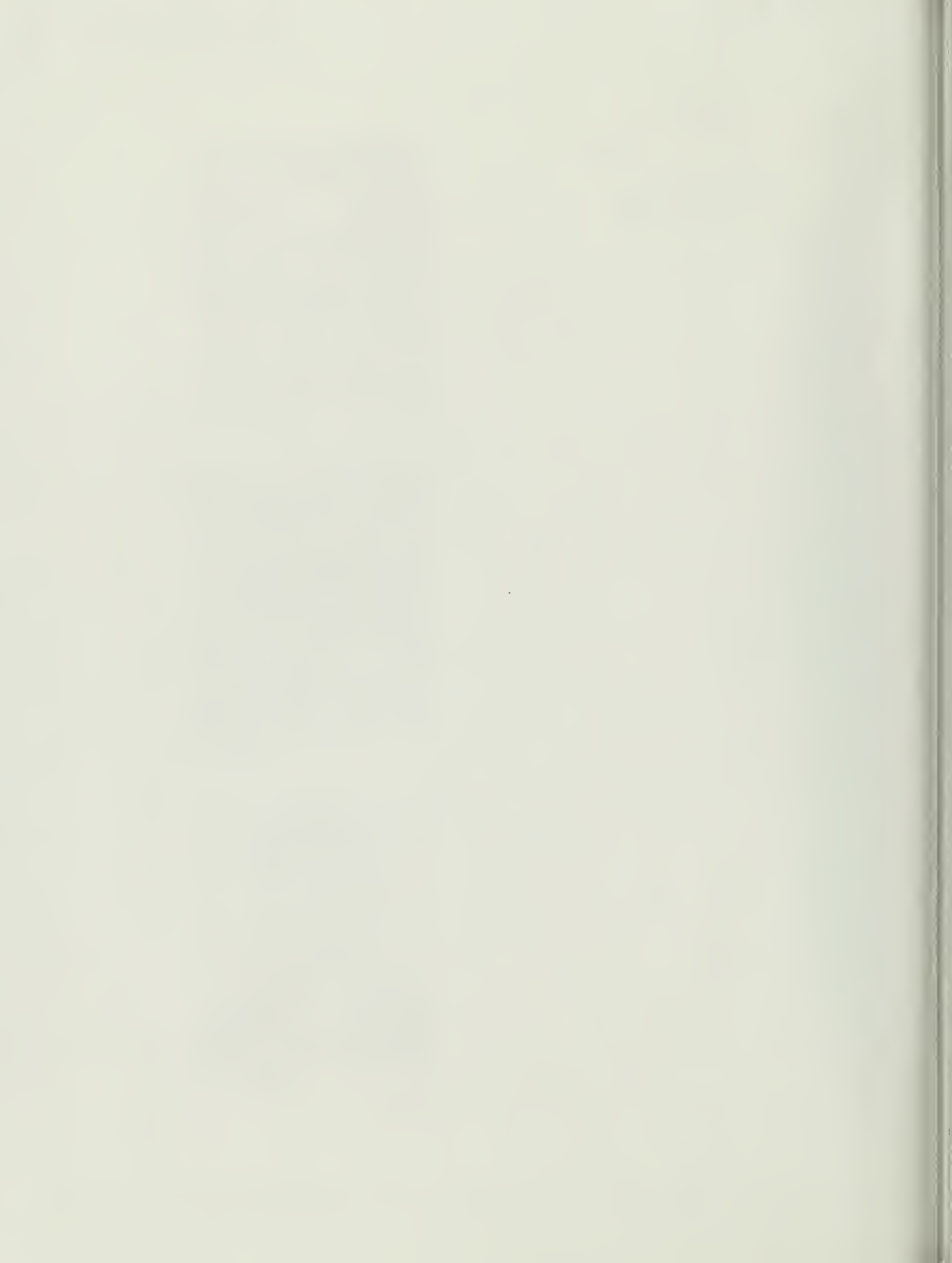


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